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ABSTRACT

This document provides instruction for high-priority competencies on task lists developed by the National Institute of Automotive Service Excellence. Contained in this teacher's guide are the materials necessary to teach 11 competency-based instructional units related to the automotive service industry. The following instructional units are included: (1) study the automotive service trade; (2) learn and apply general safety practices; (3) develop first aid skills; (4) apply related math and measuring; (5) study automotive design; (6) use automotive service reference manuals; (7) remove and install common fasteners; (8) use common hand and power tools; (9) maintain fluids and lubricants; (10) remove and replace seals and gaskets; and (11) apply related electrical principles. A short chapter that explains how the document should be used precedes the instructional materials. Instructional materials for each unit include some or all of the following elements: (1) student performance objectives; (2) suggested activities for the teacher and students; (3) "must know" content essential for meeting the cognitive objectives of the unit; (4) student handouts; (5) transparency masters; (6) student assignment sheets; (7) tests; and (8) answers to tests and assignment sheets. These elements appear on different colored pages within the document. (CML)

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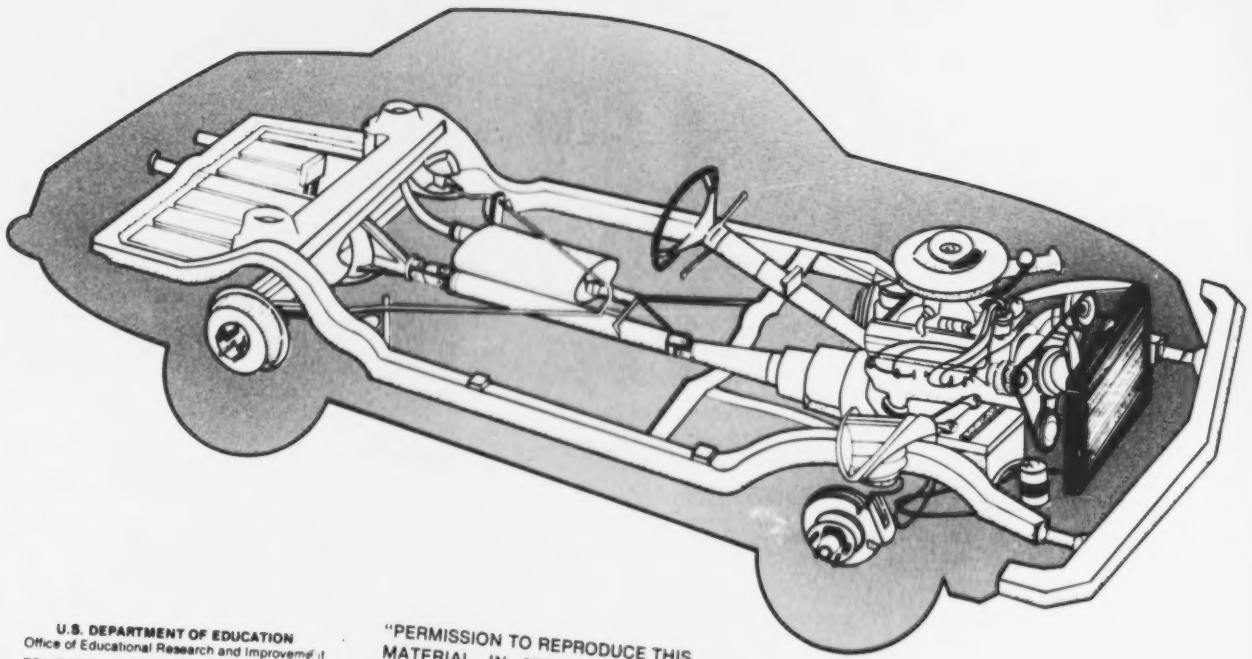
AUTOMOTIVE SERVICE SERIES

TEACHER EDITION

INTRODUCTION TO AUTOMOTIVE SERVICE

ED310278



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Stillwater, Oklahoma

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Introduction to Automotive Service

Developed by
Curriculum and Instructional Materials Center
for
Oklahoma State Department of Vocational and Technical Education

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FOREWORD

This is the first in a series of nine publications that are based on the National Institute of Automotive Service Excellence (ASE) task lists. This series provides instruction for all high-priority competencies established by ASE and will contribute greatly to an auto service technology program's ability to meet the requirements of a nationally certified training school.

The ASE competencies are developed by industry to meet the industry's need for quality technicians; therefore, this curriculum addresses this need. The industry and education committee that has validated the technical accuracy of this material must be commended for outstanding service and commitment to the quality of these instructional units. The instructors and students who use this material should be challenged to have the same commitment to excellence.

We trust that this instructional material will meet students' unique needs as they enter the "world of work."

Roy Peters, Jr., State Director
Oklahoma State Department of
Vocational and Technical Education

Ivan Armstrong, State Supervisor
Trade and Industrial Education
Oklahoma State Department of
Vocational and Technical Education

PREFACE

The purpose of *Introduction to Automotive Service* is to provide students with a core curriculum to enable them to obtain the knowledge and skills basic to workers in the automotive industry. Having gained these basic competencies, students will be prepared for study in the eight automotive specialty areas: steering and suspension, engine performance, brakes, electrical, heating and air conditioning, automatic transmission/transaxle, manual drivetrain and axles, and engine repair.

Instructors are faced with the challenge of teaching the skills and related information necessary for their students to become the highly qualified automotive service specialists that are in demand today. This curriculum guide is designed to help instructors meet this challenge. The objectives in this curriculum are based on those National Institute of Automotive Service Excellence (ASE) tasks that are common to all eight specialty areas.

ACKNOWLEDGEMENTS

Any project as comprehensive and involved as *Introduction to Automotive Service* requires the contributions of a great number of people. We are thankful for the tremendous support we have received in the development of this book.

Appreciation is given to the technical review committee members for their guidance during this project. These committee members assisted in reviewing the ASE task listings, designing the scope and sequence of all the materials contained in the automotive series, and reviewing the completed materials. The review committee included

Dewayne Arndt
Robert Betche
Dan Buckner
Charlie Brackett
Larry Grummer
Larry Hime
Jerry Kenney
Floyd King
Carroll McNish
Merlon Peace
Bedford Rowland, Jr.
Ed Tatman

In addition, appreciation is extended to those instructors who participated in field-testing these units of instruction. Thank-you goes to these instructors for all of the time and effort they devoted to using these field-test units in their programs, completing the survey forms, and attending the field-test review committee meeting. Those participating were

Dewayne Arndt
Robert Betche
Roy Boswell
Charlie Brackett
Johnny Brown
Don Doshier
David Haraughty
Dell Heavner
Joe Hileman
Larry Hime
Edward D. Humphreys
Larry Jacob
Jerry Kenney
Veachel Linville
Carroll McNish
William L. Opdyke
Bill Peters
Norman Powell
Ray Schoonmaker
Eddie Snapp

Thank-you goes to the members of the Oklahoma State Department of Vocational and Technical Education staff who made the project possible: Roy Peters, Jr., State Director; Ivan Armstrong, Trade and Industrial State Supervisor; and Greg Pierce, CIMC Coordinator.

Appreciation is also extended to the members of the CIMC project development team, under the direction of Curriculum Development Coordinator Sheila Stone, assigned to this project. This team consisted of Sue Buck, Alan Barker, Robert Hilley, Susan Walker, and me. A very special thanks is extended to Chuck Pendergast for the advice and technical expertise shared with the development team members during the production of this curriculum guide. Special appreciation goes to Anita Kroth, secretary for Curriculum Development, for her assistance throughout the development process.

Others involved in the development process also deserve special thanks. Thank-you goes to the Communications Center staff, especially Rose Primeaux, who played a significant role in finalizing the appearance of the format and who was responsible for typesetting all the units of instruction. Thank-you also goes to the many artists in the Art Department, under the direction of Bob Davis, who contributed their talents to this project. Recognition also is due to Tom Fields of the CIMC Media Unit who did the photographic work for this volume.

It is sincerely hoped that these materials will be of value to automotive service instructors and that they benefit those students who pursue careers in the automotive industry.

Marsha Sneed
CIMC Editor

INTRODUCTION TO AUTOMOTIVE SERVICE

INSTRUCTIONAL UNITS

Introduction to Automotive Service includes three sections and eleven instructional units written in a standard format established in 1970 for the development of instructional materials for all Oklahoma vocational teachers and adapted in 1986 in response to user requests. The standard format included eight basic components that formed a unit of instruction: objective sheet, suggested activities for the teacher, information sheet, assignment sheets, job sheets, transparency masters, written test, and answers to written test and assignment sheets. Depending on the specific objectives, transparency masters, assignment sheets, or job sheets may or may not have been included in a unit of instruction. In the adapted format, seven additional components have been developed to better define knowledge and skill competencies of the occupation studied. These new components are instructor supplements, pretest and answers, student supplements, activity sheets and answers, and practical tests.

All of the unit components "zero in" on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the instructor will help him or her determine the following:

- Amount of material that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media, that must be ordered.
- Resource people who must be contacted.

OBJECTIVE SHEET
(White pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the performance necessary to reach the unit objective.

The unit objective states the overall goal of the unit. It tells what the student should be able to do and what standard will be used to see whether the student can do it. Specific objectives outline the teaching sequence of the competencies required to meet the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Instructors should prepare for each unit by deciding how each objective can best be taught.

Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the instructor should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

SUGGESTED ACTIVITIES (Pink pages)

This component is included only in the instructor material. The suggested activities pages assist instructors during the preparation stage of the teaching/learning process by providing suggestions for delivery, application, and evaluation during the instructional process. Teaching suggestions are included for each objective. The instructor should read the suggested activities before teaching the units to allow time to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the instructor will vary according to the particular unit.

References used in the development of each unit are listed in the "Suggested Resources" section, along with print and nonprint media that may be used to teach the unit. These materials can be used by the instructor to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

INSTRUCTOR'S SUPPLEMENTS (Pink pages)

Instructor's supplements are optional materials for the instructor to use. They have three purposes: to provide the instructor with higher-level materials to stretch the advanced student, with remedial information or practice to assist the less advanced student, and with state-of-the-art information in which the instructor may not have a background or with information that is not readily available in other textbooks or service manuals.

TRANSPARENCY MASTERS (Pink pages)

Transparencies are graphic materials used to direct the students' attention to the topic of discussion. They may present new information, or they may reinforce information presented in the information sheet or in the assignment sheets.

PRETEST ANSWERS (Pink pages)

The answers to the pretest are given in this component along with a table that correlates the pretest items and the specific objectives.

PRETEST (White pages)

The pretests consist of multiple-choice questions designed to give students exposure to ASE-certification-style test questions. The questions duplicate the learning level of the specific objectives and include questions covering information-sheet and assignment-sheet competencies and job-sheet skills.

INFORMATION SHEET
(Green pages)

The information sheet provides "must know" content essential for meeting the cognitive objectives on the knowledge and comprehension level of Bloom's taxonomy of educational objectives. The information is presented in outline form and is keyed to the specific objectives.

Instructors will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit.

STUDENT SUPPLEMENTS
(Green pages)

Student supplements are included in the student material. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information in the completion of assignment-sheet or job-sheet objectives will be evaluated when completing those particular assignments.

ASSIGNMENT SHEETS
(Brown pages)

Assignment sheets provide students with information and exercises or problems that address learning levels at or above the application level of Bloom's taxonomy. The assignment sheets give students an opportunity to apply information they have learned or to apply nontested information presented in a student supplement. Answer sheets are provided.

ACTIVITY SHEETS
(White pages)

Activity sheets provide students with nontested activities designed to expand the students' appreciation of the subject area studied or to provide additional practice exercises over tested objectives. These activities often address the affective domain and may include such things as written or oral reports, personal inventory exercises, or additional problem-solving exercises. Answer sheets may or may not be included.

JOB SHEETS
(Blue pages)

The job sheets provide an introduction, a list of equipment and materials, and a procedure—either an outlined procedure or reference to an appropriate manual containing the procedure—needed for practicing a psychomotor skill. The introduction to the job sheet is new and provides the students with background information necessary to complete the procedure.

The instructor should discuss the introduction to the job sheet, discuss the equipment and materials used—emphasizing the specific available equipment and materials in the shop—and provide the students with demonstrations of the job-sheet procedure prior to having students practice.

Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

PRACTICAL TEST
(Yellow pages)

Practical tests provide the instructor with an instrument with which to evaluate job-sheet competencies. The instructor observes the student performing a job-sheet procedure and then evaluates both the process and the product of the procedure.

WRITTEN TEST
(Yellow pages)

This component provides criterion-referenced evaluation of every information-sheet and assignment-sheet objective listed in the unit of instruction. If objectives have been added, deleted, or modified, appropriate changes should be made on the test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

The acceptable response on a unit test, 85 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each individual test item. The final unit grade should be obtained by using both the practical test evaluations and the written test score.

ASSIGNMENT AND WRITTEN TEST ANSWERS
(Pink pages)

Assignment answers and written test answers are designed to assist the instructor in evaluation of student performances.

PAGE NUMBERING

The title of the curriculum guide, the number and title of the unit, and the page number are identified on each page of this curriculum manual. Each unit is page numbered separately. Using this page numbering system, lost or misplaced pages can easily be identified.

DISSEMINATING MATERIAL

Material may be given out a unit or page at a time to keep the material before the student always new. Some instructors ask students to furnish a three-ring binder for the current unit of study. This is convenient for taking the material home to study. Upon completion, each unit is then placed in a larger binder. The large binders may be purchased from the CIMC. Some instructors store the materials by units in filing cabinets or boxes until needed. All the units may be given out at once if desired.

For best results, provide student materials for each student. Student materials contain objective sheets, pretests, information sheets, assignment sheets, activity sheets, job sheets, practical tests, and written tests. All tests are collated at the back of student material and should be removed and stored until needed. Students should be allowed to take their materials home at the end of the course.

TEACHING METHODS

It is a challenge to keep students motivated. Instructors should supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

OBJECTIVE SHEET

UNIT A-1 STUDY THE AUTOMOTIVE SERVICE TRADE

INTRODUCTION

Today, more than 170 million cars, trucks, and buses serve the United States motoring public. Maintaining these millions of vehicles is a huge and growing industry. Americans spend billions of dollars every year for automotive parts and service. In fact, the total amount spent on motor vehicle service actually exceeds the amount spent on motor vehicle sales. Such a volume of service business offers a wide range of interesting and profitable careers for capable people. There is no question that the properly trained and motivated automotive service specialist will be in great demand in the foreseeable future.

UNIT OBJECTIVE

After completing this unit, the student should be able to describe occupations and related skills in the automotive service trade. The student will demonstrate these competencies by completing the assignment sheets and written test with a minimum of 85 percent accuracy.

PREREQUISITES

None.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with the automotive service trade by choosing the correct term from a list of four choices.

2. Identify the eight automotive service specialities according to their duties by stating the most likely specialty to perform the tasks in a given list.

3. Identify places that hire automotive service specialists by writing names of specific companies or agencies in your local area.

4. Determine training requirements for given situations. (Assignment Sheet 1)

5. Recall the steps required for ASE certification by writing the steps in the student's own words.

6. Recall the importance of personal characteristics that employers seek in employees by arranging a list of the characteristics in the same order as they were ranked by employers.

7. Analyze work situations to determine the importance of employee attitudes. (Assignment Sheet 2)

SUGGESTED ACTIVITIES	STUDY THE AUTOMOTIVE SERVICE TRADE

INTRODUCTION TO PROGRAM

- **Review materials to determine scope and sequence of program offerings, instructional approaches, and time frames.**

  1. Determine objectives that will be covered and additional objectives that must be added. Obtain materials necessary to teach, reinforce, and evaluate additional objectives.
  2. Allot time required for each unit, scheduling class periods and key events such as demonstrations, tours, and evaluations.
  3. Adapt materials and organize them to accommodate teaching approaches. For example, package materials in individual packets; reproduce supplements and transparency masters.
  4. Make alternative plans for delays, scheduling conflicts, equipment breakdowns, etc.
  5. Discuss materials and program planning with your advisory committee prior to the start of each program presentation.
  6. Survey local employers in your area to determine training needs, employment opportunities, impressions of the program, availability of support in offering the program, etc.

- **Decide equipment, facilities, staff, counseling, and other needs.**

- **Prepare classroom and shop.**

  NOTE: Remember that first impressions have a tremendous impact on your students.

  1. Be sure shop and classroom are clean and well organized.
  2. Post articles and other materials documenting student success and the potential for an excellent career in the trade.
  3. Be sure facilities promote a good learning environment—well lighted, comfortable, cheery, exciting, etc.

- **Review unit and plan presentation.**

  NOTE: This first unit has several purposes, including:

  1. Introduce students to you and to program;
  2. Acquaint students with competency-based education (CBE) and, specifically, with Curriculum and Instructional Materials Center (CIMC) instructional concepts;
  3. Prepare the students to do well in a CBE program;
  4. Introduce the students to the National Institute of Automotive Service Excellence (ASE) and the eight occupational areas;
  5. Show students that training in automotive service is an ongoing, career-long process;
  6. Begin the process of instilling in students the attitudes and work ethics that are important to employers and to the trade; and
  7. Allow the instructor to practice working with CBE and the CIMC design, while also assessing teaching and planning approaches.

  The instructor should keep these goals in mind, determine the emphasis to be placed on each, and plan the presentation for this unit.

- **Obtain materials needed to supplement unit.**

  1. Review "Delivery" section and note suggestions for media and supplemental materials.
  2. Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section.
  3. Obtain transparencies and competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- **Introduce yourself and the course to the class.**

  1. Discuss your background and experience in a factual, not boastful, way. Point out your continuing educational and technical update efforts to emphasize that a career in automotive service requires ongoing training and that this course is only the first step in a process that will continue throughout the students' careers.

2. Give an overview of the course and the total program at your institution. You may want to make handouts or transparencies of the tables of contents of the various publications used at your institution. Point out that book titles reflect occupations and unit titles describe duties within that occupation. Emphasize that this first volume covers skills and information common to all of the occupations and will help the students become employable in various pre-specialty occupations.

3. Invite graduates of the program to talk to the class about how the course qualified them for employment.

4. Use the class discussion or individual counseling sessions to plan specific needs for each student.

5. Use a panel of employers and mechanics from the various specialties to discuss their jobs, working conditions, and job availability. Carefully plan how to discuss salaries so that no one on the panel will be embarrassed or offended. For example, you may want to speak in terms of annual ranges.

6. Discuss competency-based education, relating your teaching methods and the course materials to CBE. Suggestions are provided in teaching this unit that will allow you to use this first unit to more fully explain CBE.

7. Explain your evaluation methods and class-management techniques.

8. Discuss safety and discipline.

9. Review use of tools, tool checkout procedures, and requirements for student-furnished tools.

10. Allow your students to introduce themselves and explain their interests and background experiences in automotive service. Encourage them to discuss their plans and goals in light of the course.

- **Discuss your role and the role of the students in making the course successful.**

1. Point out that training in this program is likely to be quite different from any schooling that the students may have experienced in the past. Explain that the emphasis will be on developing skills in the automotive service trade and not on grades. Explain, also, that your instruction and evaluations will be designed to help them master such skills.

2. Discuss the teaching/learning process as a team effort, requiring a lot of work from both the students and the instructor. Inform the students that they will probably have more responsibility in determining what they learn and how well they learn it than they have ever had in the past. Point out that you will be trying to help them master the skills of an automotive service specialist and that they must do their parts in reaching the goal.

3. Use *Improving Study Skills* to discuss study habits and techniques. You may want to incorporate this mini-course on developing learning skills into your presentation of this unit or you may want to present it separately. You can teach it separately during another class period, or you may teach it as required during the first week or so of instruction. For example, you may want to discuss techniques for classroom learning during the first class period, techniques to taking notes in another period prior to a film or lecture, techniques for using a reading system when you give the first extensive reading assignment, techniques for remembering prior to reviewing before a written test, etc.

   NOTE: Make it clear to your students that your techniques and these materials are designed to help them become the best automotive service specialists that they can be. Explain that your tests are meant to evaluate their abilities, not to "get them" or trick them.

- **Discuss CIMC design and competency-based education.**

1. Provide students with unit.

2. Introduce unit.

   NOTE: Suggestions for introducing the unit can be found in the "Delivery" section of this component.

3. Discuss unit and specific objectives, emphasizing how accomplishing the unit objective is an important step toward a career in the trade and how the specific objectives help the student achieve the unit objective.

   NOTE: Specific suggestions for teaching each objective can be found in the "Delivery" section of this component.

   - Explain what an objective is, perhaps relating the unit objective to a destination and the specific objectives as steps required to be taken in reaching that destination.

   - Explain that each unit will contain a list of objectives that outline the things the students should know and be able to do in order to meet the unit objective.

- Point out that the unit objective tells what the student has to be able to do and what standard will be used to see if the student can do it.

4. Discuss the CIMC components and design features.

   - Use Transparency 1, "CIMC Student Components," to discuss the various components and their functions. See upfront material in instructor's edition.

   - Mention that two other components—job sheets and practical tests—will be introduced in the next unit.

   - Discuss *notes*. Notes are used to expand information or to add nice-to-know details. They are not tested over. Two examples of notes can be found on page 36. Mention *cautions* (information needed to prevent equipment damage or minor personal injury) and *warnings* (information needed to prevent serious personal injury or death). Point out that notes, cautions, and warnings are commonly used in vehicle service manuals; show some examples.

   - Discuss boxed items. Boxed items are used to present information that expands an objective or ties an objective to other objectives. Two basic types of boxed items are used. The type shown on page 34 is an example of a boxed item that simply presents information related to the objective. The boxed item on page 35 is an example of the type frequently entitled "One step more..." This type suggests that the student do some activity to reinforce the objective or to build greater appreciation for the topic. Either type of boxed item may also contain *adjunct questions* designed to get students to think a little bit more about what they are studying.

   - Discuss the outline format used in CIMC materials. Point out that information in the information sheet is outlined in three ways. The first is shown on pages 33 and 34. **Bold type** is used to show terms or phrases that are further explained in standard type. Lists without further explanation (page 35) and lists with complete statements (page 36) are designated with bullets (•). The final outline format, shown on page 37, is the enumeration of items. This method is used on the information sheet when numerical sequence is important and a testable part of the information. Point out to students that only the information that is outlined as described above will be covered on the written test. Emphasize that material in notes, examples, and boxes will not appear on the test, but are important tools for the student in learning the tested material.

- Use Objective 1 to show students how an objective appears on the objective sheet, is taught and stated in performance terms, and is tested in some specific way.

- Use Transparency 2, "CIMC Test Indicator Actions," to discuss indicator actions used in CIMC tests. Explain each category and give examples of each. In this unit, there is at least one example of each type of indicator action. The table below shows the correlation between test indicator actions and activities in this unit.

  TABLE 1 — Correlation between indicator actions and unit activities

Indicator action	Unit activity
Essay	Objectives 5 and 7
Construction	Activity Sheet 3
Recall	Objective 2
Transfer	Objective 3
Completion	Activity Sheet 4
Alternative response	Activity Sheet 1
Multiple choice	Objective 1
Matching	Objective 4
Rearrangement	Objective 6

- Emphasize that the methods for testing objectives are designed to be as close to what is required in the trade as possible.

- Explain any special uses you make of the materials and how the materials will accommodate those practices.

  EXAMPLES: Explain how to use the open space to take notes to supplement the information. Show how the loose-leaf design allows the insertion of service bulletins and other supplements.

5. Discuss information provided for each objective.

NOTE: The recommended teaching sequence is shown on the objective sheet. For this unit, informational content for Objectives 1, 2, 3, 5, and 6 can be found in the information sheet. Student Supplement 1 provides information needed for teaching Objective 4, while Assignment Sheet 1 provides the student with practice in applying that information. Assignment Sheet 2 builds on content given in the information sheet (Objectives 1 and 6) to take the students a step further.

- Incorporate appropriate teaching suggestions as each objective is taught.
- Explain the features and purpose of each component as you cover the material.
  - For the information sheet, emphasize the methods used to outline testable information and those to distinguish nontested information (notes, examples, boxed items). Explain that the test will require answers pretty much identical to the outlined information for those objectives covered in the information sheet.
  - For the student supplement, emphasize that this component is used to provide involved information that the student must grasp in order to apply it in another way. For example, in this unit, we want the student to be able to determine sources of instruction for various training needs. Student Supplement 1, "Automotive Service Training," presents the background information needed by the student in order to do the action required by the competency (determining training sources). However, the student is not tested over his or her recall of the information as it appears in the student supplement. Instead the test addresses the student's ability to apply that information. Thus, the test responses required of the student will resemble the assignment sheet, not the supplement.
  - Explain that assignment sheets are written activities that are directly related to skills required of a person in the trade. They allow the student to practice application of skills taught in the information sheet, in student supplements, or in the assignment sheet itself. Tell students about the kinds of assignment sheets they will find in other units.

EXAMPLES: Interpret charts in reference materials, select correct fasteners for specific applications, select correct fluids and lubricants.

— Discuss the use of activity sheets. Activity sheets direct the student to do research, outside reading, a written exercise, or some other activity related to the trade but not actually required as a competency for employment. Many of these activities are intended to help the student understand the complexity of the business world and to appreciate the trade. Provide the student with examples of such activity sheets.

EXAMPLES: Investigate an accident; report on a service bulletin; determine the costs of tools; practice taking ASE-type tests

6. Using a service manual, demonstrate a simple service procedure, relating it to the appropriate specialty area(s).

NOTE: The purpose of this activity is twofold. First, it allows you to discuss job sheets and instructional techniques for psychomotor skills. Also, it allows students to get out of the classroom and into the shop.

- Use one or more demonstration procedures such as live demonstration and videotape.
- Show students what is involved in obtaining tools, materials, and references.
- During the demonstration, discuss work habits and ethics. Also emphasize safety as an introduction to the next unit.
- Discuss student practice and practical tests. Allow as many students as possible some hands-on experience by asking for volunteers. Avoid embarrassing students who are not yet confident in their skills.
- Show the CIMC job sheet for the demonstration procedure and relate it to the objectives and information in that unit.

7. Discuss student and professional organizations.

   - Relate benefits of student and professional organizations to objectives, such as training and certification.
   - Invite representatives from such organizations to talk to class about what is involved in being a member.
   - Use *VICA: Learn, Grow, Become* for a full program in promoting VICA.

8. Give written test.

   NOTE: The test is fairly simple, and you may want to complete it orally with the whole class. It is intended primarily to build student confidence and to demonstrate some of the more common testing methods. What is most important is that students understand the correlation among the test and other components in a CBE approach.

   - Point out the correlation among objectives, components, and the tests. Every objective is covered by the information sheet, an assignment sheet, or a job sheet. Additionally, objectives covered in the information sheet and those covered by assignment sheets become a test item on the written test.

9. Critique test and discuss with class.

10. Reteach and retest as required.

11. Show students competency profiles and other documentation methods.

    - Relate profiles to objectives.
    - Discuss rating scale, how you use it, correlation in the total grading process, etc.
    - Have students complete personal information on competency profiles, using either actual profiles or similar documents to provide the required information.
    - Complete appropriate section of competency profiles.

12. Discuss the students' impressions and their learning experiences with this unit. Preview next unit.

13. Discuss employment in the automotive service trade.

NOTE: If you use a cooperative approach or have students who can work during their training, you will want to emphasize job-acquisition skills at this point in your program. Otherwise, you may want to cover such skills later in this or other courses.

- Invite employers to talk to the class about what they look for when they hire.
- Invite someone from your school's placement service to explain the service to the class.
- Use Assignment Sheet 2 and Activity Sheets 1 through 3 to reinforce job-acquisition skills.
- Role-play job interviews, using actual employers when possible.

NOTE: You may want to use *VICA: Learn, Grow, Become* or other materials to expand your teaching activities in job acquisition.

DELIVERY

Unit Introduction

- Provide students with latest statistics on employment opportunities and needs in the automotive service area.
- Review want ads for employment opportunities.
- Explain the efforts made by your institution and your program to place students.
- Show film, *A Different Drum*.
- Invite former students to discuss their jobs and the benefits of the program.
- Invite employers to describe their job opportunities and what they are looking for in employees.
- Explain how you are going to use this unit to prepare students for your course. For example, if using the unit primarily to introduce students to CBE, the CIMC system, and the automotive trade, explain that the unit will be used for practice. Describe the procedures you will use to acquaint the students with the course, its materials, testing techniques, classroom methods, etc.

Objective 1 Recognize definitions of terms associated with the automotive service trade

- Some instructors cover the terms as part of their introduction to the unit or as an overview. Other instructors prefer to use the terms as a glossary.

- Show students examples of ASE task listings, tests, booklets, and certificates when discussing related terms. Make sure that students understand that ASE is the full abbreviation for the National Institute for Automotive Service Excellence.

- When discussing the terms associated with work attitudes, have the students discuss examples with which they are familiar. For example, for a high school program, you may want to relate *loyalty* to school loyalty, supporting the teams, or school pride.

- Refer the students to the objective sheet to see how this objective is to be tested and then to the written test. Discuss the multiple-choice objective application.

- Discuss the performance verb *recognize*. Tell the students that for objectives introduced by the verb *recognize* the student is expected to be familiar enough with the information to select it from among other bits of information. The test will present the information in the same form in which it appears in the student material, and the student is expected to recognize it in response to a given stimulus. Common indicator actions used to test for recognition include multiple choice, matching, and some alternative response, such as true-false items.

Objective 2 Identify the eight automotive service specialties according to their duties

- Invite technicians from each specialty area to talk about their occupations. Remember that one purpose of this first course is to allow students to become familiar with the skills, duties, and work conditions required for each occupation. These should be brought out whenever possible throughout the course so that the students can make sound job decisions in conjunction with their preferences and abilities.

- Expand the list of duties for each occupation and relate them to the training in this and subsequent courses. Have students discuss what they know about each occupation already.

- Discuss other job titles, especially those used in your region, and areas of overlap. This can be done by using want ads or employers to determine job titles.

- Use Transparency 3, "Automotive Service Specialties."

- Discuss pre-specialty occupations. Point out that completion of the training outlined in this volume will expose students to duties from each of the occupational specialties while building enough job skills that the student can find employment in many pre-specialty areas.

  EXAMPLES: Service station mechanic, lubrication shop worker, dealership make-ready person, parts shop salesperson, worker in specialty shop such as brake, muffler, or other shop

- Point out the wording of the objective. Explain to the students that *identify* is used when they must supply a name, word, or phrase in response to a given stimulus. That stimulus may consist of a symbol, category, illustration, description, or other clue that will allow a knowledgeable person to identify the stimulus.

- Discuss the use of *state*, *write*, and *list* as indicator actions. These verbs are generally used when the student must *recall* information given in the lesson. The indicator action allows the student to present information in response to a stimulus, similar to a *recognition* objective. However, in a recall objective, the student must supply the answer from memory.

Objective 3 Identify places that hire automotive service specialists

- Invite personnel managers or others responsible for hiring to discuss their procedures and what they look for in employees.

- Ask former students to discuss their hiring experiences.

- Discuss places in your community and surrounding communities that hire automotive service specialists, emphasizing those that are not so obvious.

- Use *VICA: Learn, Grow, Become* to discuss the hiring process, applications, interviews, etc. The depth to which you cover this subject will depend on your program. For example, if you incorporate OJT or cooperative hiring into your program, you may want to discuss those skills in the VICA materials required for placing the students. If your program is designed for placement after completion, you may want to teach job-acquisition skills later in the course.

- If you discuss the "One step more..." activity, have the students relate the occupational specialties to the places they find that hire service specialists. For example, what kind of specialists are likely to work in a transmission shop? A dealership? A radiator shop?

- Discuss the objectives that require students to supply examples of their own. The response that the student must give will not be found in the information sheet. This type of indicator action involves *transfer* because the students must apply classifications, principles, or guidelines that have been taught in order to arrive at their own examples.

Objective 4 Determine training requirements for given situations

- Provide pamphlets or brochures from various types of training sources. Display materials from various sources and relate the training to the purpose of each program.

- Relate the purposes to your program.

- Expand on related occupations and describe training programs available for them.

- Introduce students to professional publications, bulletins, and organizations.

- Show the film *For Years to Come*. Emphasize changes that are occurring in automotive service and the kinds of training and attitudes required to handle such change. Invite former students or employers to discuss ongoing training.

- Have students study Student Supplement 1, "Automotive Service Training," or use the supplement as the basis of a lecture. Relate information from your school's recruiting program and from those of other schools to give specific examples of the various types of training.

- Invite personnel from other training programs—especially those with which your program articulates and those which draw working service specialists as students—to discuss training and the need for career-long training.

- Point out the wording of the objective and how a matching item is set up on the test. Tell the students that matching will generally be used with a word, phrase, or symbol in order to relate to description, use, or explanation. Distractors are not used, and in most cases no more than fifteen matching items will be included.

Objective 5 Recall the steps required for ASE certification

- Invite an ASE representative, certified mechanic, or employer to discuss reasons for seeking ASE certification. Possible reasons include

  — prestige of being a proven, certified professional

  — better pay and improved job opportunities with some employers

  — an evaluation of the technician's strengths and weaknesses

  — better customer draw because of the ASE reputation

- Have students discuss where they have seen the ASE logo. Point out examples, such as on service manuals in your shop or at a service center during a field trip.

  NOTE: ASE has an ongoing program to improve the visibility of the organization among the public with the goal of making ASE a household name and the blue symbol a recognized sign of quality.

- Show the students sample tests and certificates.

  NOTE: If your program or instructors are ASE-certified, display the ASE symbol. Decals, patches, and other materials are available from the national headquarters.

- Advise the students of the ASE-accepted substitution for work experience as a result of completing an ASE-certified training program.

- Discuss reasons for trying to become a Master Automobile Technician and for recertifying.

- Have students complete Activity Sheet 4, "Complete Registration Form for an ASE Test."

Objective 6 Recall the importance of personal characteristics that employers seek in employees

- Use box material to discuss attitudes. Have students discuss their attitudes and those of others with regard to work. Ask the students their opinions of businesses, in particular automotive service businesses. Do most people think that such businesses are honest, efficient, caring, responsive to customers, or "just out to make a buck" anyway they can?

- Have local employers, especially those likely to hire your graduates, talk to your class about how important these qualities are to them, how to seek such qualities when hiring, and what their biggest attitude problems are among employees. Use guests who will be able to keep the discussion on a positive track, even when candidly discussing problems.

- Show *Eye of the Supervisor* and *Your Job: Good Work Habits*.

- Use the objective sheet and test to discuss *arrange-in-order* objectives. Point out that the order may be a memorized sequence such as this one or it may be based on some principle such as time or importance or quantity. A similar objective is the *rank-in-order* objective in which the sequence is based on quality or the application of a rating system. Rank-in-order objectives address the evaluation level of learning.

- Have students complete Assignment Sheet 2, "Analyze Work Situations to Determine the Importance of Employee Attitudes," and discuss in class.

- Have students complete Activity Sheet 1, "Evaluate Your Work Attitudes." Help students individually to create plans for improving areas of weakness. As you discuss such plans, mentally note how you can assist the student in attitude improvement through the learning activities of the course.

SUGGESTED RESOURCES

Resources used in developing unit

- ASE. "ASE Tests," booklet. Washington D.C.: National Institute for Automotive Service Excellence, 1985.

- ASE. *Task Listing for NATEF Automobile Technician Training Certification Program.* Reston, Virginia: National Institute for Automotive Service Excellence, 1985.

  NOTE: ASE materials may be ordered from National Institute for Automotive Service Excellence, 1920 Association Drive, Reston, Virginia 22091-1502.

- Bloom, Benjamin S., *et al. Taxonomy of Educational Objectives, Handbook I: Cognitive Domain.* New York: David McKay Co., Inc., 1956.

- Brewer, Margaret, *et al. Life Skills Attitudes on the Job.* New York: Educational Design, Inc., 1980.

- Oklahoma State Department of Education. *One of a Kind: A Practical Guide to Learning Styles.* Oklahoma City: State Department of Education, 1982.

  NOTE: The above publication is available to Oklahoma teachers from the State Department of Education, Curriculum Division, Oliver Hodge Building, Oklahoma City, Oklahoma 73105.

- Patton, Bob, *et al. VICA: Learn, Grow, Become.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1984.

- Tesolowski, Dennis G. *Job Readiness Training Curriculum.* Menomonie, Wisconsin: University of Wisconsin-Stout, 1979.

Media

NOTE: The following films are available to Oklahoma teachers on a free-loan basis. Oklahoma teachers may order these films from the Oklahoma State Department of Vocational and Technical Education, CIMC Film Library, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Out-of-state teachers must order from the addresses listed with the films.

- *A Different Drum.* Color, 21 minutes, Brigham Young University, 1982. Available from Jacob's House Media Marketing, Provo, Utah 84602. Featuring an all-Native-American cast, this film tells the story of a boy whose plans to become an auto mechanic conflict with his family's desire for him to attend college.

- *Your Job: Good Work Habits.* Color, 13 minutes, Coronet Films, 1969. Available from Coronet Films, Inc., 65 E. South Water St., Chicago, Illinois 60601. This film emphasizes the importance of on-the-job attitudes, concentration, planning, care, accuracy, and other habits in the quality of work and amount of job satisfaction.

- *For Years to Come.* Color, 26 minutes, Chrysler Corporation. Available from Chrysler Corporation Film Library, 9th Floor, 1430 Broadway, New York, New York 10018. This film clarifies the need for continuing training in the automotive service profession.

- *Eye of the Supervisor.* Color, 8 minutes, National Educational Media, 21601 Devonshire St., Chatsworth, California 91311. This film covers some basic principles of employee evaluation.

- *VICA: You're No. 1.* Color, 5 minutes, VICA, 1980. Available from National VICA Office, 105 N. Virginia Ave., Falls Church, Virginia 22046. This VICA promotional film discusses vocational education and VICA student activities.

Other media

- *Automotive Career Opportunities Program.* This kit contains handouts, a slide program, script, and instructions for use. The program discusses career opportunities in the automotive aftermarket industry from manufacturing sales to service station technicians. Available from Automotive Service Industry Association, 444 North Michigan Avenue, Suite 2000, Chicago, Illinois 60611.

- *Working in the Automotive Trade.* A four-part filmstrip with sound. Covers service station attendant, parts dealerships, auto mechanics, and body repair by describing tasks, working conditions, and training requirements. Available from Vocational Media Associates (Prentice-Hall Media), P.O. Box 1050, Mount Kisco, New York 10549-9989. Call toll free 1-800-431-2266.

- *Careers in Automotive Service and Repair.* Produced by Pathescope Educational Media. This sound filmstrip is built around five interviews with mechanics, body repairers, and service managers. Those interviewed talk about the job they do and their working conditions. Available from Vocational Media Associates at the above address.

- *Career Tracks: An Introduction to Professional Automotive Service Technicians.* An upbeat videotape that does a good job of getting teenagers acquainted with automotive service. Produced by automotive industry companies in cooperation with the American Vocational Association. Available from National Automotive Technicians Education Foundation, Inc., 1920 Association Drive, Reston, Virginia 22091-1502.

- *NIASE.* This 11-minute slide-tape program explains the ASE certification program. Available from Wagner Division, McGraw-Edison Company, 6400 Plymouth Avenue, St. Louis, Missouri 63133.

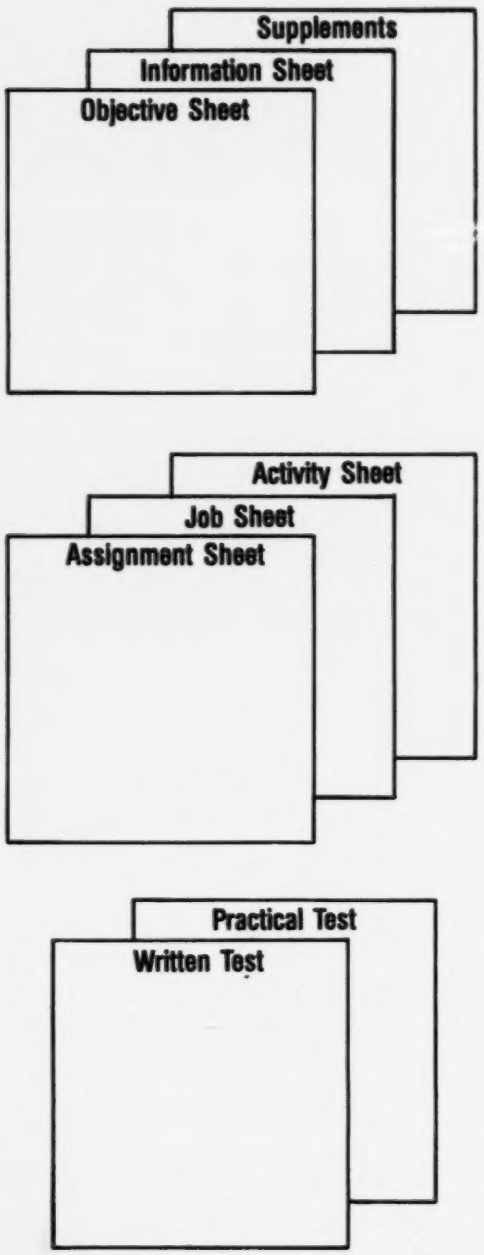
- *VICA: Learn, Grow, Become*

- *Improving Study Skills*

- Competency profiles and transparencies

  NOTE: The books *VICA: Learn, Grow, Become* and *Improving Study Skills*, competency profiles for this manual, and transparencies for this manual are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

CIMC Student Components



CIMC Test Indicator Actions

- Essay
- Construction
- Recall
- Transfer
- Completion
- Alternative response
- Multiple choice
- Matching
- Rearrangement

Automotive Service Specialties

- Engine repair specialist
- Automotive transmission/transaxle specialist
- Manual drivetrain and axles specialist
- Suspension and steering specialist
- Brakes specialist
- Electrical systems specialist
- Heating and air-conditioning specialist
- Engine performance specialist

ASE CERTIFIED

National Institute for
AUTOMOTIVE
SERVICE
EXCELLENCE

PRETEST ANSWERS

STUDY THE AUTOMOTIVE SERVICE TRADE

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 19, 31
2	2, 3, 20, 21
3	13, 14, 27
4	16, 17, 28
5	4, 22, 32, 33
6	11, 12, 24, 34
7	25, 26
8	5, 23
9	6, 7, 8, 9, 10, 33
10	15, 29, 35
11	18, 30

ANSWER KEY

1.	b	9.	a
2.	d	10.	c
3.	d	11.	a
4.	a	12.	b
5.	d	13.	b
6.	b	14.	d
7.	a	15.	c
8.	b		

PRETEST

STUDY THE AUTOMOTIVE SERVICE TRADE

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which of the following is the best definition of *automotive service*?

   a. Length of time a vehicle has been used
   b. Maintenance and repair of vehicles and the various components used in vehicles
   c. Products available at service stations
   d. Use of vehicles by the military

2. Which of the following is **not** something that normally would be serviced by an *engine repair specialist*?

   a. Engine lubrication system
   b. Engine cooling system
   c. Engine exhaust system
   d. Engine computer system

3. ASE is the abbreviation for _____.

   a. Automotive Specialty Engineers
   b. Automotive Service Enterprises
   c. National Automotive Technicians Education Foundation
   d. National Institute for Automotive Service Excellence

4. One of the requirements for ASE certification is _____ years of hands-on experience or a combination of one year of hands-on experience and a period of acceptable training.

   a. 2
   b. 3
   c. 4
   d. 5

5. Which of following may hire an automotive service specialist?

   a. New-car dealerships
   b. Dairies that have a fleet of delivery trucks
   c. Department stores
   d. All of the above

6. A recent survey showed that the quality that employers want most in their workers is _____.

   a. Technical knowledge
   b. Honesty
   c. Skill in the use of tools
   d. Cooperativeness

7. Technician A went to a high school vocational program for his _____.

   a. Initial automotive service training
   b. Automotive engineering training
   c. Specialized diagnostic equipment training
   d. None of the above

8. An automatic transmission/transaxle specialist is likely to work on which of the following?

   a. Hydraulic systems for brake systems
   b. Hydraulic systems for automatic transmissions
   c. Hydraulic systems for shock absorbers
   d. All of the above

9. Technician B works on starting, charging, lighting, signaling, and other such systems. He is _____ specialist.

   a. An electrical systems
   b. A manual drivetrain and axles
   c. A brake
   d. An engine performance

10. To be certified as a *Master Automobile Technician* a person must pass _____ of the ASE tests.

    a. 4
    b. 6
    c. 8
    d. 10

11. Technician A overslept and was late for work. Technician B told her to tell their boss that she had had a flat. Technician A felt she should tell the truth and apologize. Who is right?

    a. Technician A
    b. Technician B
    c. It depends on the boss
    d. It depends on how often Technician A is late

12. Technician A says that she wishes all of the mechanics in her shop were as good as she is. The problem with such an attitude is that _____.

    a. She may become frustrated if she is not getting paid more than the others
    b. She may not give other people the credit they deserve and may fail to see how they can help her
    c. She may have to spend too much of her time helping the other mechanics
    d. There is nothing wrong with her attitude as long as she is right about being the best and honest with others that she is

13. A person who is in a formal program in which he or she works with professionals in a trade to learn the skills involved is in an _____ program.

    a. Automotive service training
    b. Apprenticeship
    c. Accelerated professional trade school
    d. Individualized, self-paced training

14. Which of the following are reasons for automotive service technicians undergoing training?

    a. To learn more about an occupational specialty
    b. To learn about new developments in technology
    c. To learn how to use a special piece of equipment
    d. All of the above

15. An ASE technician must recertify every _____ years.

    a. 2
    b. 3
    c. 5
    d. 7

INFORMATION SHEET

STUDY THE AUTOMOTIVE SERVICE TRADE

OBJECTIVE 1

Recognize definitions of terms associated with the automotive service trade

Automotive service — Maintenance and repair of vehicles and the various components used in vehicles

Trade — A specific industry or group of businesses related by a common product, process, or service

Specialist — Someone who works in a limited area of a trade, especially someone who has a high degree of knowledge and highly developed skills within that area

ASE — Abbreviation for National Institute of Automotive Service Excellence, a nonprofit corporation that works to ensure that high-quality automotive service and repair are available

NATEF — Abbreviation for National Automotive Technicians Education Foundation, an organization that develops and encourages technical education for automotive service specialists

Certification — Recognition by a certifying agency for someone who has reached a certain level of professional development by meeting standards set by the agency

Apprenticeship — Formal program of training in which a student works with professionals in a trade to learn the skills involved

NOTE: The definitions below list characteristics that employers have said are most important to them when hiring someone. They are important characteristics for an automotive service specialist to have.

Honesty — Quality of a person who is truthful, fair, and straightforward

Reliability — Quality of a person who is dependable, who can be counted upon

Cheerfulness — Quality of a person who tends to be happy and hopeful, and who encourages others to be so

Diligence — Quality of a person who gives steady, earnest, and energetic effort to a task, who keeps trying patiently until the task is done

Enthusiasm — Quality of a person who shows interest in and excitement for what he or she is doing

Cooperativeness — Quality of a person who is willing and able to work with others, to share in the labor and rewards

Loyalty — Quality of a person who is faithful to another person or organization, who supports the other through words and actions

OBJECTIVE 2

Identify the eight automotive service specialties according to their duties

Engine repair specialist — Services mechanical portions of engine and related components used to start and run the engine, lubricate it, cool it, and remove exhaust

Automatic transmission/transaxle specialist — Services the hydraulic and mechanical systems, controls, and linkages for automatic transmissions and transaxles

Manual drivetrain and axles specialist — Services clutches, shafts, joints, and gear systems for manual transmissions and transaxles

Suspension and steering specialist — Services suspension, manual and power-steering components, and tire and wheel assemblies

Brakes specialist — Services mechanical and hydraulic components for brake systems

Electrical systems specialist — Services starting, charging, lighting, signaling, and instrumentation systems as well as electrically operated accessories

Heating and air-conditioning specialist — Services mechanical, electrical, and fluid components for the refrigeration, heating, and ventilating systems

Engine performance specialist — Services ignition, fuel, emission control, cooling, and related mechanical and electrical systems for efficient engine performance

National Institute for Automotive Service Excellence

The National Institute for Automotive Service Excellence (ASE) is a nonprofit corporation dedicated to improving the quality of automotive service and repair. ASE's primary method for promoting quality is through voluntary certification of technicians and automotive training programs. Working with representatives from all sectors of the automotive industry, training facilities, government agencies, and consumer groups, ASE has set up a certification program with high standards. In the process, they have identified the eight occupational specialties listed above. Your instructor can provide you with information about ASE and can arrange for you to talk to ASE-certified technicians.

OBJECTIVE 3

Identify places that hire automotive service specialists

- Service stations
- Automotive dealerships, new and used
- Independent garages
- Companies that maintain vehicle fleets

  EXAMPLES: Trucking companies, bus lines and taxi services, companies that deliver products or services in their own vehicles, car rental companies

- Government agencies

  EXAMPLES: Motor pools, universities, forestry service trucks

- Department stores and discount stores
- Specialty service centers

  EXAMPLES: Muffler shops, brake shops, radiator shops, tire centers, transmission shops, automotive parts stores

One step more . . .

The use of vehicles is an important part of our lives that affects us every day—from the farm implements that harvested the grain you ate for breakfast, to the way you came to class, to the trucks that delivered the bedding you'll sleep on tonight. Look in the Yellow Pages of your local telephone directory to see how many listings there are of potential jobs for you. Check some of the following listings.

- ☐ Automobile Air-Conditioning Equipment and Service
- ☐ Automobile Dealers
- ☐ Automobile Diagnostic Services
- ☐ Automobile Electric Service
- ☐ Automobile Lubricating Service
- ☐ Automobile Machine Shop Service
- ☐ Automobile Motor Rebuilding
- ☐ Automobile Radios and Stereo Systems
- ☐ Automobile Renting and Leasing
- ☐ Automobile Repairing and Service
- ☐ Mufflers and Exhaust Systems—Engine
- ☐ Transmissions—Automobile

OBJECTIVE 5

Recall the steps required for ASE certification

- Complete two years of hands-on work experience or one year of hands-on experience and a period of ASE-accepted training

Substitutes for Work Experience

ASE recognizes the value of training and will accept training as a substitute for one year of hands-on experience. Training may consist of any of the following or a combination of the following:

High school training—Three full years if successfully completed
Post high school training—Two full years
Short courses—Two months of short course will be accepted for one month of hands-on experience

- Apply for certification
- Pass ASE test

  NOTE: ASE gives tests in each of the eight specialty areas twice each year. You may take the tests prior to completing the work-experience requirement, but a certificate will not be issued until both requirements have been met.

- Pass all eight tests to be certified as a *Master Automobile Technician*
- Recertify every five years by completing a recertification test

  NOTE: Recertification tests are given once each year for each occupational area. Recertification tests contain half as many questions as the initial certification tests and are required to maintain certification.

ASE Tests

Your instructor can provide you with more information about ASE training and sample ASE test questions. Each unit in this series contains a test designed in the ASE format in addition to the written test over specific objectives. Discuss ASE testing and the use of ASE-type tests with your instructor.

OBJECTIVE 6

Recall the importance of personal characteristics that employers seek in employees

1. **Honesty**
2. **Reliability**
3. **Cheerfulness**
4. **Diligence**
5. **Enthusiasm**
6. **Cooperativeness**
7. **Loyalty**

Attitudes

A general rule about getting and keeping a job is that you're hired based on your skills and fired based on your attitudes. What this means is that a person may have been trained to do a job, such as being an automotive brakes specialist. The person may even be very skilled at that job, and those skills may impress an employer so that the brakes specialist is hired. However, if after the person is hired, he or she turns out to be lazy or uncooperative, dishonest or unreliable, that person may lose the job. The purpose of any training program should be more than just helping you find a job. The training should also help you to keep the job, to find satisfaction in your work, and to get promoted to higher-paying and more responsible positions. Therefore, you must learn to work with not only tools, materials, vehicles, and reference materials, but also with bosses, co-workers, and customers. As a result, during your training you will study not only the information and procedures required in performing automotive service, but you will also study and practice attitudes important to your job success.

STUDENT SUPPLEMENT 1

Automotive Service Training

INTRODUCTION

Ask any mechanic who has been in the trade for several years, and he or she will tell you that cars and trucks have changed a great deal. Vehicles are now equipped with components that did not even exist a few years ago. Automotive shops use modern tools and test equipment to diagnose and repair malfunctions. These devices use the latest technology to perform their tasks better, and more advanced service products appear almost every day. Because such developments are likely to continue, a person starting a career in automotive service should realize that training will continue through the rest of his or her career. To remain employed, the automotive service specialist will have to keep up with the latest technological advances in automotive design and with the techniques and equipment used to service advanced vehicles.

Additionally, many service specialists will choose to learn new skills. These skills may include those required of a particular occupational specialty area, such as heating and air-conditioning specialist or engine performance specialist. After a few years as a service technician, the person may want to move into shop management. These and other jobs require additional skills that are not learned in a basic automotive service program.

This supplement will familiarize you with some of the reasons persons pursuing a career in automotive service require training and where they can go to get it. After you have studied this supplement and as you develop your own training plan, talk to your school's counselors and to your instructors about specific training requirements and where you can get the training you need.

PURPOSES

Training requirements change as you go through your career in automotive service. Thus, the purpose of each type of training is slightly different to satisfy the various training requirements. Everyone has to begin somewhere, so entry-level training is required by everyone entering the trade. Whether they get that training in a formal program, such as high school or community college courses, or by working in a shop to learn the trade, all service specialists learn the basics somewhere. Once a worker has entered the trade, he or she may choose to go into one of the specialty areas or into a different related occupation, such as automotive body repair or automotive engineering. During the person's career, he or she will also need training to learn about the latest technological developments or the use of specialized equipment or methods. Generally, then, we can classify training by its five purposes:

- Entry training

- Occupational specialty training
- Technology-update training
- Specialized equipment or process training
- Related occupational training

SOURCES

Many kinds of institutions offer automotive service training, ranging from public schools to private schools to private companies. Some of these agencies may offer training that fulfills all or several of the purposes discussed above, while other agencies may offer training for only one of those purposes or may offer training only at certain times. Some of the training from these agencies is open to anyone, while some institutions train only select groups, such as their own employees or users of their products. The list below outlines the most common sources of automotive service training.

- High school vocational programs
- Professional trade schools
- On-the-job or apprenticeship training
- College and junior college programs
- Vehicle manufacturer's training centers
- Component or equipment manufacturer's training programs

  EXAMPLES: Diagnostic equipment training, alignment equipment manufacturer's workshop, exhaust system manufacturer's course

- Company- or agency-run training programs

  EXAMPLES: Dealerships, military training

- Workshops and short-term courses for special requirements

  EXAMPLES: Asbestos safety training, vehicle recall service training, technological updates

By understanding your training needs as an automotive service specialist and by knowing where such training is available, you should be able to enjoy a long and rewarding career.

ASSIGNMENT SHEET 1

STUDY THE AUTOMOTIVE SERVICE TRADE

OBJECTIVE 4

Determine training requirements for given situations

Name _____ Score _____

INTRODUCTION

Successful employment in the automotive service trade requires that a person have a number of varied skills. During his or her career, the automotive service specialist will be required to learn additional skills in order to tackle new responsibilities and to keep up with changes in automotive technology. Thus, the service specialist must be able to determine what training is required at various points in his or her career. Additionally, the specialist must be able to locate sources of the required training. Read Student Supplement 1, "Automotive Service Training," and start thinking about your career goals and planning how to reach them. This assignment sheet will allow you to practice matching sources of training to specific training needs.

DIRECTIONS

Ten situations describing training requirements are given below on the left. On the right are descriptions of training sources. Write the number of the *most* appropriate training source for each situation in the space by that situation. Although more than one training source may seem right for any situation, there is one that is most appropriate for each situation.

Situation	Training
_____a. An employee in a dealership who is a general mechanic but wants to become a specialist	1. A professional trade school offers courses in all eight specialty areas to students who have already mastered basic skills
_____b. A graduate of a basic automotive service program who would like to receive specialty training by working with professionals in the trade under a formal training program	2. A junior college offers a two-year associate degree in automotive service, with in-depth courses offered in four of the occupational specialty areas

_____c. A service specialist working in a shop that does state safety inspections must learn the techniques involved in testing exhaust gases under the new inspection requirements

_____d. A service specialist who must learn to use the new engine diagnostic equipment her company has just purchased

_____e. A high school junior who would like to learn the automotive service trade and receive high school credit for the courses

_____f. A service specialist who works for a moving company would like to become a shop manager

_____g. A high school graduate who has completed a basic automotive course and who would like to learn all eight specialty areas and eventually become a Master Technician

_____h. A high school graduate who has completed a basic automotive course and two specialized courses who would like to go to college to learn to design vehicles

_____i. A service specialist in a Buick dealership who needs to service the new-model cars

_____j. A high school graduate who would like to get some college training without necessarily going for four years and would like to study at least two specialty areas

3. A regional vocational-technical center offers high school juniors and seniors courses in automotive service

4. A dealership offers training so that its general mechanic employees can upgrade to specialty areas

5. An automotive service professional organization sponsors apprenticeship in all eight specialty areas for graduates of basic service courses

6. A state college offers courses and a degree in automotive engineering

7. A manufacturer of engine diagnostic equipment provides short courses in the use of the equipment to customers

8. A training center run by General Motors Corporation conducts courses to train people to service the latest design features on GM vehicles

9. A state sponsors workshops to train safety inspection shops to perform new inspection requirements

10. A nation-wide moving company runs a training center where they train service specialists to become shop managers

ASSIGNMENT SHEET 2

STUDY THE AUTOMOTIVE SERVICE TRADE

OBJECTIVE 7

Analyze work situations to determine the importance of employee attitudes

Name _____ Score _____

INTRODUCTION

The program in which you are enrolled is designed to teach you the knowledge and skills that you will need as an automotive service specialist. However, surveys of employers repeatedly show that their workers' skills are generally good enough and that poor job knowledge is seldom a primary reason for an employer's being unhappy with a worker. Usually, the leading reason for such dissatisfaction is that the employee has poor work habits. Although this includes such things as tardiness and goofing off, more often it means not taking care of tools, working unsafely, showing disrespect toward customers or their property, not using common sense, and other attitudes and actions. In fact, one recent survey showed that the seven most important characteristics that employers seek in their workers are

1. Honesty
2. Reliability
3. Cheerfulness
4. Diligence
5. Enthusiasm
6. Cooperativeness
7. Loyalty

Many employers feel that a worker with good attitudes and good work habits can be taught the required skills, but that even the most skilled employee isn't worth keeping if he or she has a bad attitude or poor work habits.

DIRECTIONS

In this assignment, you will be given several situations and asked to identify the character trait or traits from the list above that is missing in the actions described. You will discuss this assignment in class or with your instructor.

1. There are lots of cases of engine oil in the shop where Doug works. He sees nothing wrong with helping himself to a can occasionally. He's sure that no one will miss it. Besides, he feels that it makes up for his not being paid enough. What's wrong with what Doug is doing? What future dangers exist if he continues this attitude?

_____

_____

2. Jill had a great time with her friends last night. She knew at the time that she should get home because of having to work today, but she was just having such a good time that she stayed out late. This morning, she had her roommate call in sick for her. Did she do the right thing?

3. Mac has just told Sergio about a co-worker named Milan. Mac overheard the shop manager bawling out Milan for doing a poor tune-up on a car, and threatening to fire him if it happened again. Mac and Sergio laughed about it because they consider Milan to be a nerd, even though Milan has tried to help each of them. What attitude problem exists, and how do you think it affects the quality of work in the shop?

4. Mike works slowly and carefully and always does a good job on any task that is given to him. But there are some jobs that he does not like to do. Whenever one of them is scheduled, Mike slows down even more or pretends that he has run into a problem until one of the other mechanics gets the next job. What do you think of what Mike is doing, and what quality does he lack?

5. Glenda dropped an air-impact wrench that she had been using. When she tried it again, it wouldn't work. She decided that she wouldn't report it because no one would know who did it after she returned the wrench to the tool room. What did Glenda do wrong? How should she have handled the situation?

6. Sonya never seems to be happy with things in the shop. She complains constantly that other mechanics tease her, that it is too hot or too cold or too dirty, that the equipment isn't modern enough, that the customers are idiots, and so on. Her boss is especially worried because her attitude seems to be rubbing off on other workers. What do you think Sonya needs more of and what would you think of working with a person like Sonya?

_____

_____

_____

7. Ralph was out with some of his friends. He had had a bad day and was angry about a couple of things that had happened at the shop. As a result he began telling his buddies about how backward the management at his shop is, how poorly qualified the workers are, and how they overcharge and cheat people. None of these things were true, and normally Ralph was proud of his shop. What characteristic was lacking in Ralph's actions, and how do you think he felt about it later?

_____

_____

_____

8. Felix is usually a good worker, but he is not very patient. If he is working on a car and things do not go smoothly, he gets upset. If things continue to go wrong, he is likely to give up on the task. Sometimes, he even takes short cuts. For example, today he was having trouble getting all the bolts to line up on a part, so he left out one bolt and tightened the others extra hard. What is Felix's problem, and what further problems do you think it may lead to?

_____

_____

_____

ASSIGNMENT ANSWERS	STUDY THE AUTOMOTIVE SERVICE TRADE

ASSIGNMENT SHEET 1

a.	4	f.	10
b.	5	g.	1
c.	9	h.	6
d.	7	i.	8
e.	3	j.	2

ASSIGNMENT SHEET 2

Answers will vary.

ACTIVITY SHEET 1

Evaluate your work attitudes

Name _____

INTRODUCTION

You have learned in this unit that attitudes can be just as important as technical knowledge and job skills in career success. Your attitudes will affect how well you will do in your career and how well you will do in this training program. Automotive service has changed in many ways due to technological advances. One attitude that you must develop is that you will have to study and practice throughout your career to stay current in the trade. You will also find that many customers do not trust automotive service specialists. Thus, the abilities to work with people, to be a good listener, and to be thought of as honest and sincere will help you to succeed in the automotive service trade. How well do you measure up?

In this assignment, you will get a chance to evaluate yourself in terms of your work attitudes. This assignment is for your own use. You do not need to share this information with anyone. Instead, use it to determine areas in which you need to improve. If you think that you could use some help in one or more areas, talk to your instructor about ways you can improve those attitudes and habits. If you do not feel comfortable asking for help this early in the training program, wait until you know your instructor better and discuss it then.

Save this activity sheet; and as you go through your training, look at it again from time to time and ask whether your score has improved.

DIRECTIONS

Read the following list of actions and estimate how much they apply to you. Write an "X" over the number for how frequently you do the action described. If you do not work, consider how often each action is true for you in school.

	Often	Sometimes	Never
1. Missing work	1	2	3
2. Arriving late for your job	1	2	3

		Often	Sometimes	Never
3.	Being extremely friendly with your supervisor	1	2	3
4.	Being extremely aggressive with your supervisor or co-workers	1	2	3
5.	Talking to your supervisor or co-workers when they do not want to be bothered	1	2	3
6.	Expressing anger when your work is constructively criticized	1	2	3
7.	Allowing your emotions to affect your work	1	2	3
8.	Treating co-workers unfairly	1	2	3
9.	Taking full credit for a group effort	1	2	3
10.	Breaking company rules and policies	1	2	3
11.	Trying to be the first person out of the building after work	1	2	3
12.	Expressing superiority to your supervisor or co-workers	1	2	3
13.	Allowing comments or criticisms about your work to become personal	1	2	3
14.	Indicating that you are more important than anyone or anything else concerned with your job	1	2	3
15.	Trying to gain personal advantages	1	2	3

		Often	Sometimes	Never
16.	Asking your supervisor a lot of unnecessary questions	1	2	3
17.	Verbally or nonverbally telling your supervisor or co-workers that you are smarter or have a better education than they	1	2	3
18.	Taking problems to higher management than your immediate supervisor	1	2	3
19.	Being extremely sensitive to comments made by your supervisor or co-workers	1	2	3
20.	Making excuses when problems arise	1	2	3
21.	Complaining and finding faults with everything	1	2	3
22.	Blaming co-workers for your mistakes	1	2	3
23.	Doing personal tasks during work hours, such as reading magazines or writing letters	1	2	3
24.	Being extremely critical of your supervisor, co-workers, or the company you work for	1	2	3
25.	Trying to learn co-workers' jobs before you know your own	1	2	3
26.	Complaining about anything associated with your job	1	2	3

		Often	Sometimes	Never
27.	Watching the clock while working	1	2	3
28.	Ignoring safety rules	1	2	3
	Totals	_____	_____	_____
	Grand total			_____

To see how well you are doing, total the score for the answers you marked. Check rating below.

75-84 points—*Excellent.* Keep up the good work and try harder on the few weak areas.

60-74 points—*Good.* Think of ways to overcome the weak areas.

45-59 points—*Fair.* Several areas need improvement. Decide which are most important and work on them first.

28-44 points—*Poor.* Quite a few areas need improvement. You need to develop a plan for overcoming weak areas.

Job-readiness checklist adapted from *Job Readiness Training Curriculum* by Dennis G. Tesolowski, copyright 1979. Used with permission of the University of Wisconsin-Stout.

STUDY THE AUTOMOTIVE SERVICE TRADE

ACTIVITY SHEET 2

Explore automotive service job opportunities

Name _____

INTRODUCTION

You are enrolled in a course of study that can provide you with an interesting, rewarding—often demanding—career. The automotive service trade is full of opportunities for qualified people. The trade offers jobs that involve a wide variety of skills and various working conditions.

When selecting a job or a career, a person must consider many questions that center around: Will the work and the pay, including benefits, be worth my while? In making that decision, a person may examine some of the factors listed below.

- How much will I actually earn?—This question is more than just asking how much your salary will be. Salary is just one consideration.

  You must also consider what your *take-home pay* will be. This is the amount you actually get when you pick up your check. Take-home pay will be less than your salary because of *deductions*. Money is deducted, or subtracted, from your pay for state and federal taxes and Social Security payments. These amounts are based on your salary and will be about the same no matter where you work (within the same state) if the salaries of the jobs are approximately the same. However, other deductions vary from job to job. For example, a payment for health or other insurance may be deducted. Similarly, the employee may be charged for union dues, uniform fees, work area or tool fees, a retirement program, or other costs. These will vary from job to job.

  When asking how much money you will earn, you must also ask how much money you will have to pay in order to work there. The cost may be like a uniform expense deducted from your paycheck or an expense paid from your pocket such as what it costs you to drive to work.

  You will also want to consider the value of *benefits* provided by the company. Benefits are those things a company gives to a worker other than salary, such as vacation time, paid holidays, sick leave, paid insurance, paid retirement funds, and others. Benefits may make the difference between which job actually pays better.

EXAMPLES: If two jobs pay the same salary but one offers one week of paid vacation while the other offers two weeks, you would actually have to work one week longer at the first job to earn the same salary.

In another example, if one employer pays for your health and life insurance while another doesn't, you will have to deduct what you have to pay for insurance when you compare salaries.

- Will the job be satisfying?—Will you be happy working at the job? If you have allergies, you probably would not be happy working in a floral shop. But there may also be things about working in automotive service that you do not like. Automotive service can be dirty, physically exhausting, and mentally frustrating when you face a problem that appears to have no solution. On the other hand, the work can be very satisfying. You can have a feeling of accomplishment when you do a job well. A career in automotive service is a vital contribution to other people and to society. The work is seldom boring because every procedure on a different vehicle is unique. You must also consider whether a job will help you to reach your goals—both personal and career goals.

This activity sheet will help you to explore job opportunities and career choices in the automotive service trade. It consists of two parts. In the first part, you will consider your goals and how to reach them. In the second part you will consider a specific job opening.

DIRECTIONS PART A

Think about what your goals are in studying automotive service and then answer each item below.

1. Which of the following descriptions best describes your reasons for taking this course? (Check the one that best applies.)

   _____a. I am interested in a career in automotive service.

   _____b. I just want to learn about working on cars.

   _____c. I am not sure whether I want to make automotive service a career, but I thought it might be interesting to check it out.

   _____d. Automotive service is a stepping-stone to another career in which I am interested.

   _____e. None of the above statements tell why I enrolled in the class.

2. From what I know about automotive service and myself, the occupational specialties in which I am most interested are _____. (Check each one that applies.)

   _____a. Engine repair specialist

   _____b. Brakes specialist

   _____c. Suspension and steering specialist

   _____d. Automatic transmission/transaxle specialist

   _____e. Manual drivetrain and axles specialist

   _____f. Heating and air-conditioning specialist

   _____g. Electrical systems specialist

   _____h. Engine performance specialist

3. From what I know about automotive service and myself, the occupational specialties in which I am definitely **not** interested are _____. (Check each one that applies.)

   _____a. Engine repair specialist

   _____b. Brakes specialist

   _____c. Suspension and steering specialist

   _____d. Automatic transmission/transaxle specialist

   _____e. Manual drivetrain and axles specialist

   _____f. Heating and air-conditioning specialist

   _____g. Electrical systems specialist

   _____h. Engine performance specialist

4. My highest career goal is _____.

NOTE: If you do not know what your career goal is, you may go on to PART B.

5. To reach my goal, I plan to take the following schooling and work in the jobs listed.

   _____

   _____

   _____

   _____

DIRECTIONS PART B

Find an advertisement for an automotive service job opening. Obtain enough information about the job to answer the following questions.

1. What will be my take-home pay? _____

   Salaries and wages are often quoted by employers as gross earnings. Gross earnings are used because tax deductions vary according to the number of dependents, the amount of earnings, and other information.

   Wages offered automotive specialists are usually based either on a commission pay plan (the specialist is paid a percentage—often 45 to 50 percent—of the labor charge for all jobs performed during the pay period) or a flat-rate pay plan (the specialist is paid a fixed hourly rate per flat-rate hours accumulated for all jobs performed during the pay period). Commission pay changes when the labor rate changes; flat-rate pay does not.

   Optional benefits and deductions offered by an employer also differ. It is generally advisable to ask what programs are available for enrollment as these can affect the actual money you receive on payday.

2. What are the benefits that accompany the job? (List job benefits on the blanks below.)

   Some benefits associated with working are not always visible. Often some of these overlooked benefits are paid for in part by your employer. At the time of the interview, or when considering a position, ask about employer's contributions for your protection, which may include

   - Health insurance
   - Unemployment compensation
   - Clothing and safety garments; cleaning of clothing
   - Medical facilities and health tests
   - Pensions
   - Travel insurance (covering mishaps when traveling on business)
   - Training programs or reimbursement for courses related to job; certification training
   - Sick leave with pay
   - Paid vacations and holidays

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

3. How much will it cost to actually be at work each day?

The costs associated with being employed are often overlooked. It may be of value to calculate estimated weekly expenses before you make a decision about a job.

Estimate weekly expenses for the following.

Transportation (parking, bus fares)	$_____	Tools	$_____
Lunches (or cost of food eaten brought from home, including soft drinks and coffee)	$_____	Special uniforms, materials, or equipment for job	$_____
Clothing (including cleaning)	$_____	Other: Professional dues, employee funds, miscellaneous expenses	$_____
Child care for working parent	$_____	**TOTAL**	$_____

4. What is important to me in a job?

Take-home pay and benefits may be only part of what you want from a job. Think through other things you consider important in a job.

What were three of the most rewarding things about any job you have ever had?

a. _____

b. _____

c. _____

How might you rate the following items in order of importance to you? Number in order of importance the three items most important to you.

_____ Job security (little chance you will be released from the job)

_____ Opportunity for advancement

_____ Recognition for your work

_____ Good wages

_____ Opportunity to learn and use your ideas

_____ Flexible working hours

_____ Long vacations

_____ Pleasant working conditions

_____ Interesting work

_____ Friendly co-workers

_____ Other _____

5. Are you ready to decide?

   Take all of the information you have gathered and summarize it below and on the next page to reach a decision about whether you want the job or not.

   a. Will the job be satisfying to me? Why/why not?

   _____

   _____

   _____

   b. What are the benefits that accompany the job?

   _____

   _____

   _____

   _____

   c. What do I estimate job benefits to be worth?

   $_____

   d. How much will it actually cost me to be at work each day?

   _____

   _____

   _____

   e. What do I estimate my take-home pay to be?

   $_____.

   f. What do I estimate my weekly expenses related to working to be?

   $_____.

   g. How will the job meet my needs and goals?

   _____

   _____

   _____

h. What would I enjoy most about this job? _____

_____

_____

i. What would I dislike most about this job? _____

_____

_____

ACTIVITY SHEET 3

Write a letter of application for a job

Name _____

INTRODUCTION

Your training is designed to help you find a job or to find a better job if you are already working. Whichever is the case, you will no doubt someday find a job for which you want to apply. There are several ways of finding out about job openings. You may see an advertisement in a newspaper or hear about the job from a friend or relative or you may be told about the job by a state or private employment agency.

Once you are aware of a job opening, you may have a choice of ways to apply for the job, unless the ad specifies "apply in person only" or some other approach. "In person" is one such approach. This means that you actually visit the company. More than likely, they will have you fill out an application and will either interview then or will arrange an interview later if your application interests them.

Another way of applying for a job is to call the company. Often companies will list only a telephone number in their ads so that they can talk to applicants before they visit the office. In this way, they can *screen* applicants—that is, choose the ones they want to have come to the office.

Screening is also done through letters. Some companies require people to apply for jobs in writing, frequently by what is called a *blind ad*. A *blind ad* does not identify the company offering the job. A blind ad may give only an address, often a box number at the newspaper running the ad. Companies do this for various reasons. Sometimes they do not want their employees to know that a job is available, but more often it is just because they do not want a lot of people visiting or calling their office.

Automotive service jobs may require or allow any of the application methods discussed. Most will allow the applicant to apply in person. But many positions, especially advanced positions, will require a letter of application. Even if you plan to apply for a job in person, there are many reasons for writing a letter of application. First, a letter of application tells the employer that you are a prepared, organized person—something many employers look for when hiring workers. Second, a letter of application can be left with the employer after an interview or with a completed application form. The letter will help the employer remember you among the crowd.

Another advantage of a carefully prepared letter of application is what it can do for you personally. Writing such a letter will help you organize your thoughts. It will force you to think about your strengths and weaknesses in terms of the job. This can be a big help if you are interviewed for the job. What you write in the letter may help you answer interview questions or make your answers clearer and better thought out.

This assignment sheet provides you with guidelines for preparing a letter of application. By following these guidelines and writing an application letter for any job in which you are interested, you will improve your chances of getting the job.

INTRODUCTION

Study the guidelines below and on the following pages and the sample letter on the last page. Then select an automotive service job advertisement from a newspaper, one for which you would actually like to apply now or later in your training. On a separate piece of paper, write a letter of application for the job opening, following the guidelines in this activity sheet. You will discuss your letter with your instructor.

NOTE: This objective is not covered on the written test.

- **Use acceptable form and appearance**

  Type or write neatly

  Type or write on only one side of the paper

  Avoid smudges and typographical errors

  Use 8 1/2-by-11-inch white bond paper, not personal or fancy paper

  Spell, capitalize, and punctuate correctly

  Write employer's full name, title, and address

  Include on the letter your full name and address with zip code

  Keep a copy for future reference

- **Include proper information**

  Write to a specific person

  NOTE: Find out the name of the personnel manager/employer you want to reach and the correct title. When in doubt, write to the top person who will refer your letter to the right party. Write "To Whom It May Concern" if answering a blind ad.

Avoid excessive use of the pronoun "I"

State the position for which you are applying

Avoid needless details

Cover all points requested in the advertisement in exactly the order in which they were asked

NOTE: Some prospective employers make a point of testing the applicant's ability to follow directions.

State reason for interest in job

NOTE: Employers look for people who want future advancement opportunities rather than just a paycheck.

Request an interview at the employer's convenience

Tell how you can be reached

- **Make the letter upbeat, positive, and interesting**
- **Include the current date**
- **End the letter properly**

  NOTE: *Sincerely yours* or *Very truly yours* is appropriate.

- **Use your permanent address for the return address**

219 Maple Street
Dayton, OK 77702
April 14, 1988

Mr. David Miller, Owner
Miller Automotive Repair Shop
Box 136
Collierville, OK 77708

Dear Mr. Miller:

Please consider me for the job of brakes specialist that you advertised in the *Daily Chronicle* on April 9. I will be graduating from Dayton High School in May. During the past two years, I have studied automotive service and will have completed the Brakes Specialist course prior to graduation.

My training has included all the skills mentioned in your ad. The school will gladly provide you with a listing of my ratings for skills covered in the course. Additionally, I have passed the ASE certification tests for Suspension and Steering Specialist and for Brakes Specialist. My instructor, Mr. Hardin, can verify my skills and the fact that I am a fast learner and a safe worker with the kind of work attitudes you want.

I do not have the one year of work experience you specify in the ad. However, my training has emphasized hands-on experience, and I worked in a local repair shop for almost three months last summer. I am confident that my training, limited experience, and dedication qualify me for the opening. I understand that you have hired graduates from our program and are familiar with the quality of training provided at Dayton High.

I meet the other qualifications that your ad specified, including my own hand-tool set, which was purchased with money I earned last summer. A list of references is attached.

I would appreciate the opportunity to discuss the job at a time convenient for you. I can be reached at 405-555-4433 after 4:00 p.m. or at the address above.

Sincerely yours,

Terry McKracken

Terry McKracken

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ACTIVITY SHEETS	STUDY THE AUTOMOTIVE SERVICE TRADE

ACTIVITY SHEET 4

Complete registration form for an ASE test

Name _____

INTRODUCTION

As you continue your career in automotive service, you will probably become involved with professional trade organizations. You will take additional training courses to improve your skills. You will also look for other ways to make yourself more employable, to improve your position with your employer, or to earn pay raises. One means of accomplishing these goals is to become certified by ASE in one or more specialty area. Ultimately, you may want to become certified in all eight areas so that you may earn the title of Master Automobile Technician.

To reach these goals, you must study, gain work experience, and pass the ASE tests. ASE requires that each person who wants to take an ASE test must complete a registration form. This activity sheet will give you practice in registering for an ASE test.

DIRECTIONS

Fill out the form on the following pages. Answer each item carefully, noting areas in which you need more training or experience. Discuss this activity sheet with your instructor.

Registration Form
ASE Tests
Fall 1987

Deadline Date October 2, 1987

If extra copies are needed, this form may be reproduced.

Important: Read the *Booklet* first. Then print neatly when you fill out this form.

1. a. Social Security Number ___ - ___ - ____

1. b. Telephone Number (During the day) ___ (Area Code) ___ - ____ (Number)

1. c. Previous Tests: Have you ever registered for an ASE certification tests before? ○Yes ○No

2. Last Name **First Name** **Middle Initial**

3. Mailing Address (See page 11.)

Number, Street, and Apt. Number

City State ZIP Code

4. Date of Birth ___ Month ___ Day ___ Year (See page 11.)

5. Sex: Blacken one circle. 1○Male 2○Female

6. Race or Ethnic Group: Blacken one circle. (Not required; see page 12.)

1○American Indian
2○Black
3○Caucasian/White
4○Hispanic/Mexican
5○Oriental/Asian
6○Puerto Rican
7○Other
(Specify) _____

7. Education: Blacken **only one** circle for the highest grade or year you completed.

Grade School and High School (including Vocational)	*After* High School Trade School or Technical (Vocational) School	College
○7 ○8 ○9 ○10 ○11 ○12	○1 ○2 ○3 ○4	○1 ○2 ○3 ○4 ○More

8. Employer: Which of the below best describes your current employer? (Blacken **one** circle.)

1○New Car/Truck Dealer, U.S.—
2○New Car/Truck Dealer, Import—
Enter code for make of car or truck (see page 16) ___
3○Service Station—Enter code for oil company (see page 16) ___
4○Military—Enter code for military branch (see page 16) ___
5○Independent Garage
6○Fleet Service Shop
7○Specialty Shop
8○Government/Civil Service
9○Student
10○Educator/Instructor
11○Manufacturer
12○Independent Body/Paint
13○Mass Merchandiser
14○Tire Dealer—Enter code for tire dealer (see page 16) ___
15○Other

9. Release of Information (See page 14 for details.)

1○I agree 2○I do not agree that parties approved by ASE may be told which tests I have passed

10. Test Center (See the list of test centers on pages 14 and 15)

Center Number _____ City _____ State _____

11. Tests: Blacken the circle(s) for the test(s) you plan to take. **Note:** Do not register for more than four tests per session.

November 10

- ○ A2 Auto: Automatic Trans/Transaxle
- ○ A3 Auto: Manual Drive Train and Axles
- ○ A6 Auto: Electrical Systems
- ○ A7 Auto: Heating & Air Conditioning
- ○ T3 H-D Truck: Drive Train
- ○ T4 H-D Truck: Brakes
- ○ T5 H-D Truck: Suspension & Steering
- ○ B1 Body: Body Repair
- ○ B2 Body: Painting & Refinishing

November 12

- ○ A1 Auto: Engine Repair
- ○ A8 Auto: Engine Performance
- ○ A4 Auto: Suspension & Steering
- ○ A5 Auto: Brakes
- ○ T1 H-D Truck: Gasoline Engines
- ○ T2 H-D Truck: Diesel Engines
- ○ T6 H-D Truck: Electrical Systems

12. Fees Number of tests marked above is: _____ x $10 = $_____

Registration Fee + $ 10

Enclose a check or money order for the total fee, made payable to **ASE/ACT** and mail to **ASE/ACT, P.O. Box 4007, Iowa City, Iowa 52243.** Don't send cash.

Total Fee = $_____

13. Fee Paid By: 1 ○ Employer 2 ○ Technician

14. Experience: Blacken one circle. (To substitute training or other appropriate experience, see page 13.)

1 ○ I certify that I have two years or more of full-time experience (or equivalent) as an automotive technician or in body/paint repair. (Fill in 15 below.)

2 ○ I don't yet have the required experience. (Skip 15 below.)

15. a. Employers: If you claimed two years of experience in 14 above, list **all** your employers for the two years. List your current employer first. Then list your previous employer. If self-employed, list the name and address of your shop.

Important: If you've had more than two employers during the two years, list the other employer(s) on a separate sheet. Attach the sheet to this form.

1. _____ From ____ ____ To ____ ____
   Current Employer — Month Year — Month Year

   Number & Street

   City — State — ZIP Code — Telephone Number

2. _____ From ____ ____ To ____ ____
   Previous Employer — Month Year — Month Year

   Address

b. Job Details: In this space, give details about the kinds of repair work you have done during the two-year qualifying period listed above. (If you sent in the details earlier, you can leave this space blank.)

16. Authorization: By signing and sending in this form, I accept the terms set forth in the *Registration Booklet* **about the tests and the reporting of scores.**

Signature _____ Date _____

Mail this form and a check or money order for the total fee to: **ASE/ACT, P.O. Box 4007, Iowa City, Iowa 52243.**

Registration form courtesy of ASE.

WRITTEN TEST

STUDY THE AUTOMOTIVE SERVICE TRADE

Name _____ Score _____

OBJECTIVE 1

Read the definitions below and the terms listed with each definition. Choose the term best defined by the definition. Write the number of the term in the space provided by the definition.

_____a. Maintenance and repair of vehicles and the various components used in vehicles

1. Automotive service
2. Automotive sales
3. Automotive design
4. Service specialist

_____b. A specific industry or group of businesses related by a common product, process, or service

1. Business
2. Industry
3. Trade
4. Company

_____c. Someone who works in a limited area of a trade, especially someone who has a high degree of knowledge and highly developed skills within that area

1. Worker
2. Specialist
3. Generalist
4. Employee

_____d. Abbreviation for National Institute for Automotive Service Excellence, a nonprofit corporation that works to ensure that high-quality automotive service and repair are available

1. NIFASE
2. ASE
3. NATEF
4. NatSE

_____e. Abbreviation for National Automotive Technicians Education Foundation, an organization that develops and encourages technical education for automotive service specialists

1. NIASE
2. ASE
3. NATEF
4. Natetef

_____f. Recognition by a certifying agency for someone who has reached a certain level of professional development by meeting standards set by the agency

1. Certification
2. Apprenticeship
3. Evaluation
4. Recognition

_____g. Formal program of training in which a student works with professionals in a trade to learn the skills involved

1. Certification
2. Apprenticeship
3. Evaluation
4. Recognition

_____h. Quality of a person who is truthful, fair, and straightforward

1. Honesty
2. Reliability
3. Cooperativeness
4. Loyalty

_____i. Quality of a person who is dependable, who can be counted upon

1. Honesty
2. Reliability
3. Diligence
4. Loyalty

_____j. Quality of a person who tends to be happy and hopeful, and who encourages others to be so

1. Diligence
2. Cooperativeness
3. Cheerfulness
4. Loyalty

_____k. Quality of a person who gives steady, earnest, and energetic effort to a task, who keeps trying patiently until the task is done

1. Diligence
2. Cheerfulness
3. Enthusiasm
4. Loyalty

_____l. Quality of a person who shows interest in and excitement for what he or she is doing

1. Reliability
2. Cheerfulness
3. Enthusiasm
4. Cooperativeness

_____m. Quality of a person who is willing and able to work with others, to share in the labor and rewards

1. Reliability
2. Cheerfulness
3. Enthusiasm
4. Cooperativeness

_____n. Quality of a person who is faithful to another person or organization, who supports the other through words and actions

1. Honesty
2. Reliability
3. Cooperativeness
4. Loyalty

OBJECTIVE 2

Read each list of tasks given below. In the space provided, write the title of the specialty area most likely to perform the tasks in the list.

_____ a.
- Balance tire and wheel assemblies
- _____
- Inspect and repair power-steering pump
- Replace shock absorbers

_____ b.
- Reassemble an engine
- Replace oil pump
- _____
- Adjust engine intake and exhaust valves

_____ c.
- Set ignition timing
- Adjust carburetor
- _____
- Test emission-control sensors

_____ d.
- Remove an automatic transaxle
- _____
- Pressure test an automatic transmission
- Replace transmission filter

_____ e.
- Test alternator
- Recharge battery
- _____
- Replace computer-control module

_____ f.
- Adjust clutch
- Balance driveshaft
- _____
- Replace manual-transmission shift linkage

_____ g.
- Replace brake shoes
- Bleed air from brake system
- _____
- Adjust parking-brake cable

_____ h.
- Replace air-conditioning refrigerant
- _____
- Test heat-switch electrical circuit
- Disassemble air-conditioner compressor

OBJECTIVE 3

The chart below lists seven types of places that hire automotive service specialists. The chart also provides spaces for two examples of each type of place. Complete the chart by writing the specific name of a company or agency in your local area.

Hiring place	Example 1	Example 2
Service stations		
Automotive dealerships		
Companies that maintain vehicle fleets		
Government agencies		
Department stores and discount stores		
Independent garages		
Specialty service centers		

OBJECTIVE 4

The list below on the left describes situations in which a person requires training for a career in automotive service. On the right are descriptions of training sources. Match the training requirements to the training source by writing the number of the correct source in the space by each situation.

Situation

_____a. Terry, a high school student, has decided to become an automotive service specialist, but would also like to finish high school

_____b. Having completed a basic automotive service course while in high school, Terry begins to work in an independent garage and would like to study to become an engine performance specialist

_____c. Terry, now a certified engine performance specialist, goes to work for a Ford dealership and must learn about the company's new models

_____d. Terry's company has purchased the latest in electronic tune-up and diagnosis equipment, which Terry must now learn to operate

_____e. Terry's employer would like to promote Terry to service manager, but insists that Terry develop supervisory and management skills

Training

1. A professional trade school that offers day-time classes in automotive service and night-time classes in service management
2. A vocational training center that cooperates with Terry's high school by offering basic automotive service and other technical courses to high school students
3. An equipment manufacturer who specializes in electronic diagnostic equipment and offers workshops in its use
4. A junior college that offers day and night courses in all eight ASE specialty areas
5. A training center operated by Ford Motor Company that specializes in training service people to work on their products

OBJECTIVE 5

Recall the steps required for ASE certification. List the steps involved in becoming a Master Automotive Technician and remaining certified. Write your answers on the blanks provided. The steps do not need to be listed in any particular order.

a. _____

_____

_____

b. _____

_____

_____

c. _____

_____

_____

d. _____

_____

_____

e. _____

_____

_____

OBJECTIVE 6

Below are listed the seven characteristics that a recent survey of employers showed were most important for an employee to have. They are not listed in the order that the survey group ranked them. Arrange them in the correct order by writing a number in each blank. Write a "1" beside the characteristic rated as most important, a "2" beside the second most important, and so on.

_____a. Diligence

_____b. Honesty

_____c. Cooperativeness

_____d. Enthusiasm

_____e. Reliability

_____f. Loyalty

_____g. Cheerfulness

OBJECTIVE 7

Read each case study below and determine the personal characteristic that is weak or missing. For each situation write a few sentences that identify the weak characteristic and that answer the questions presented in the case study.

a. Russell is a fairly good service specialist. However, he never offers to help any of his co-workers. When they ask for help, he usually makes excuses about being too busy at the moment. What characteristic is weak or missing? What can Russell do to overcome this problem?

b. Cheryl is a good worker sometimes, but at other times she doesn't seem to care. She does her work, but leaves as soon as the day is over. Often she works slowly and occasionally she skips procedure steps, does not look up all specifications, and is not as careful as she needs to be. What is Cheryl's problem and how can she overcome it?

c. Chen's friend has brought a car in for service at the shop where Chen works. Chen picks up the work order for the service, which calls for a tune-up and some periodic maintenance. Chen performs the service, including a change of spark plugs and the addition of almost a pint of automatic transmission fluid. Chen decides that no one will know if he doesn't list the spark plugs or transmission fluid, and it will save his friend some money. What characteristic does Chen lack and what should he do to overcome the problem?

NOTE: Turn in your test to your instructor, who will grade the test and determine if additional training is needed.

WRITTEN TEST ANSWERS

STUDY THE AUTOMOTIVE SERVICE TRADE

OBJECTIVE 1

a. 1
b. 3
c. 2
d. 2
e. 3
f. 1
g. 2
h. 1
i. 2
j. 3
k. 1
l. 3
m. 4
n. 4

OBJECTIVE 2

a. Suspension and steering
b. Engine repair
c. Engine performance
d. Automotive transmission/transaxle
e. Electrical systems
f. Manual drivetrain and axles
g. Brakes
h. Heating and air-conditioning

OBJECTIVE 3

Answers will vary.

OBJECTIVE 4

a. 2
b. 4
c. 5
d. 3
e. 1

OBJECTIVE 5

a. Complete two years of hands-on work experience or one year of hands-on experience and a period of acceptable training
b. Apply for certification
c. Pass ASE test
d. Pass all eight tests to be certified as a Master Automobile Technician
e. Recertify every five years by completing a recertification test

OBJECTIVE 6

a. 4
b. 1
c. 6
d. 5
e. 2
f. 7
g. 3

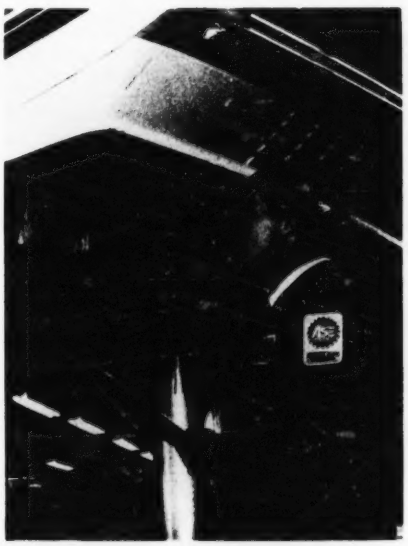
OBJECTIVE 7

a. Cooperativeness
b. Diligence
c. Honesty

OBJECTIVE SHEET

UNIT A-2 LEARN AND APPLY GENERAL SAFETY PRACTICES

INTRODUCTION



In 1985, 14,861 workers died while on the job. Another 46,219 received permanently disabling injuries. The automotive service specialist performs tasks every day that could lead to an accident. Additionally, the automotive shop is full of possible hazards. Vehicles on lifts, batteries, flammable materials, and other dangers require automotive shop workers to be careful at all times. The information and skills covered in this unit can help the student become a safe worker who is alert to these dangers.

UNIT OBJECTIVE

After completing this unit, the student should be able to apply general safety rules on the job. The student will demonstrate these competencies by completing assignment sheets, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit A-1, "Study the Automotive Service Trade."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with general safety practices by choosing the correct definition from a list of three choices.
2. Recall job safety rules by stating each rule when given a key word or phrase from the rule.
3. Analyze shop situations for safety violations. (Assignment Sheet 1)
4. Properly lift a heavy object. (Job Sheet 1)

5. Raise a vehicle with a frame or bumper jack and place on jack stands. (Job Sheet 2)

6. Handle and store flammable materials and toxic substances. (Job Sheet 3)

7. Operate exhaust-removal equipment. (Job Sheet 4)

8. Determine colors used in the safety color code by stating the color to look for in a given situation.

9. Raise a vehicle on a hydraulic lift. (Job Sheet 5)

10. Determine the correct fire extinguisher to use for various classes of fires by selecting which illustrated extinguishers could be used. (Assignment Sheet 2)

SUGGESTED ACTIVITIES	LEARN AND APPLY GENERAL SAFETY PRACTICES

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain transparencies and films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Review unit and other safety regulations to make sure that your shop is in compliance. Display posters, charts, and safety signs. Place safety precautions and operating instructions near equipment.

- Provide students with Supplement 7, "Shop Readiness Test." Supplement 7 is designed to test general safety practices common in automotive shops. Students should be required to achieve 100 percent before being allowed to perform procedures of any nature in the shop.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss introduction to the unit (see "Objective Sheet").
- Provide students with the latest injury and death statistics for job-related accidents, emphasizing those statistics for automotive trades if available.
- Tour the shop, and point out potential hazards.
- Invite persons who have suffered disabling accidents on the job to talk to the class about safety.
- Explain the penalties for safety violations in your class.
- Show the students a practical test and point out how safety is figured into the overall score.
- Provide students with copies of Supplement 1, "Safety Pledge," and require that the pledges be signed by the proper people before the students operate equipment.

Objective 1 Recognize definitions of terms associated with general safety practices

- Provide the students with examples to illustrate terms whenever possible. For example, demonstrate *extinguishing* a fire.
- Post signs, posters, and pamphlets that have illustrations of the terms.
- Copy and hand out Supplement 2, "Safety Crossword Puzzle"; inform students of how the assignment should be completed and how it will be used in class, for grades, etc. For example, you may let students work on it throughout the teaching of this unit or you may allow them to work in teams.

Objective 2 Recall job safety rules

General rules

- Invite safety experts, automotive technicians, and those who have been injured on the job to discuss job safety rules.
- Discuss with students any other safety rules that apply in your shop.
- Use Student Supplement 1, "Auto Repair Shop Safety Hazards," to discuss hazards in the shop. Have students suggest others. Emphasize how observing safety rules can minimize the dangers.

- Discuss OSHA and other regulatory acts and agencies.
- Show films, *Safety in the Shop: Basic Practices* and *How to Avoid 16 Leading Causes of OSHA Citations*.
- Explain accident reporting procedures.
- Point out locations of safety equipment.
- Demonstrate use of safety equipment, and discuss emergency procedures, including fire evacuation, adverse weather procedures, etc.

Dress rules

- Prescribe dress for the shop, and demonstrate the dangers of improper dress. For example, show how dangling jewelry could contact batteries, how long hair can snag on structural parts, how loose clothes can get caught by fans and belts, etc.
- Discuss the dangers of practical jokes and horseplay.

Equipment-and-tool rules

- Show photos of actual pieces of equipment that have been damaged through unsafe practices or misuse.
- Demonstrate a few specialty tools and compare their efficiency to trying to make do with other tools not designed for the job. Explain that tools and their uses will be discussed in more detail in a later unit.
- Use lifting as an example of work that tools can help accomplish, and teach proper lifting.
- Provide students with Supplement 3, "How to Lift Safely," and discuss lifting.
- Show films, *A New Way to Lift*, *The Industrial Weightlifter II*, and *Danger Zone: Your Back*.
- Demonstrate proper lifting techniques using Job Sheet 1, "Properly Lift a Heavy Object."
- Allow students to practice proper lifting until they are ready to take the practical test.
- Point out safety rules in the operator's manuals of various pieces of equipment. Point out safety notices on the equipment itself. Explain that none of the students will be allowed to operate equipment until they have shown that they know the safety rules for that equipment.

- Discuss policies on reporting defective tools.
- Demonstrate the use of bumper and frame jacks on various vehicles. Point out operating instructions in owner's manuals, service manuals, and vehicle storage compartments.
- Show what can happen with an incorrectly operated jack, including vehicle body damage.
- Allow students to practice Job Sheet 2, "Raise a Vehicle with a Frame or Bumper Jack and Place on Jack Stands," using various types of jacks and vehicles. Have students practice procedures until they are ready to take the practical test.

Work-area rules

- Show film, *Housekeeping Means Safe Keeping.*
- Discuss storage locations and the importance of an organized work area.
- Explain housekeeping policies and procedures. Assign housekeeping duties and discuss schedule rotation if used.
- Point out aisles, exits, and traffic areas. Relate these to evacuation procedures.
- Spill some oil or other slippery fluid and discuss those dangers.
- Demonstrate clean-up procedures.

Flammable-materials-and-toxic-substance rules

- Point out flammable materials and toxic substances in your shop. Discuss Job Sheet 3, "Handle and Store Flammable Materials and Toxic Substances," and demonstrate procedures used for substances found in your shop.
- Provide pamphlets, photographs, or other material describing toxic hazards in the automotive repair shop.
- Invite victims of asbestosis, skin cancer, lead poisoning, and other toxic hazards to speak to the class about their experiences.
- Provide students with labels from flammable materials and toxic substances. Discuss the warnings and the prescribed first-aid actions. Quiz students on their understanding of the label by giving situations that could occur in the automotive repair shop.

- Demonstrate or have the local fire department demonstrate the flammability of gasoline and how dangerous it can be if used carelessly. One method is to pour gasoline—not an excessive amount—on a pair of coveralls, hang them in an open area, and toss a match on them.

- Demonstrate stop, drop, and roll. Allow students to practice.

- Allow students to handle and store flammable materials and toxic substances as required in your shop, including transferring between containers, disposing of oily rags and waste materials, etc.

- Have students practice procedures in Job Sheet 3 until they are ready to take the practical test.

Vehicle rules

- Explain rules for vehicle operation in your shop. For example, you may require a valid driver's license for any operation of a vehicle or a spotter whenever a vehicle is backed.

- Discuss accidents that you or the students have had while operating a vehicle, especially those that occurred during driving similar to what is done in the shop: backing, parking, running over low objects, etc.

- Discuss carbon monoxide. Point out that there are carbon monoxide and other poisons in vehicle exhaust whether "smoke" is seen or not.

- Demonstrate the use of your shop's exhaust-removal equipment. Explain policies and procedures concerning its use.

- Allow students to practice Job Sheet 4, "Operate Exhaust-Removal Equipment," until they are ready to take the practical test.

- Show how hot some parts get during vehicle operation. You may want to get temperature sticks such as those used by welders and melt them on hot components. Discuss thermostat operating temperatures, and provide information or articles on the dangers of hot catalytic converters, such as grass fires.

- Discuss the handling of batteries. Show corrosion that has resulted from battery acid. Display tools or other metal objects that have been damaged by batteries.

- Discuss the use of safety belts. Watch a film on traffic safety, or invite a law enforcement official to discuss the use of safety belts. Display posters promoting the use of safety belts, such as those available from vehicle manufacturers using famous race car drivers.

Objective 3 Analyze shop situations for safety violations

- Provide students with assignment sheet after discussing safety rules. Have them complete the assignment and discuss in class.

Objective 8 Determine colors used in the safety color code

- Point out the use of the safety color code in your shop and in other shops in your training facility.
- Discuss labeling of defective equipment in your shop.
- Find out if any students are color blind, and offer them special assistance in identifying color code applications.
- Have students complete "One step more. . ." on page 69 and discuss in class.
- Demonstrate the use of hydraulic lift equipment and service pits if your shop has them. Point out safety colors used with this equipment. Emphasize safety instructions, including those contained in the operator's manual.
- Allow students to practice Job Sheet 5, "Raise a Vehicle on a Hydraulic Lift" until they are ready to take the practical test.
- Have students complete "One step more. . ." on page 70 and discuss in class.

Objective 10 Determine the correct fire extinguisher to use for various classes of fires

- Use Student Supplement 2, "Classes of Fires," to discuss the classes of fires, emphasizing examples that are likely to be found in the automotive repair shop.
- Point out locations of fire extinguishers. Discuss the classes of fires for which each extinguisher is suitable. Describe situations in the shop, and ask students how they would respond and what fire extinguisher could be used.
- Use Transparencies 1 through 4 to discuss fire extinguisher labeling.

- Use Transparency 5, "Fire Triangle," and its overlays to discuss the fire triangle.
- Use Supplement 4, "Chemical Chain Reaction," and Supplement 5, "Fire Extinguishment Theory," to discuss fire extinguishment.
- Show film, *Stop a Fire Before It Starts*.
- Invite a firefighter to discuss fires and to demonstrate the use of fire extinguishers. Emphasize that the wrong fire extinguisher or the right one used improperly can actually make a fire worse.
- Review fire alarm, notification, and evacuation procedures.
- Have students complete Assignment Sheet 2 and then discuss in class.

Unit summary activity

- Discuss Activity Sheet 1, "Investigate an Accident." The purpose of the activity is to bring about positive behavioral changes in the affective domain by broadening the student's understanding of causes of accidents; their effects on workers, employers, and others; and the importance of prevention. Consider these things when discussing the assignment.
- Use the accident reports in Supplement 6, "Activity Sheet 1 Accident Reports."
- Have actual accident victims re-create their accidents.
- Ask garage owners to share actual accident reports.

  NOTE: Be sure to change the names of the persons involved if actual accident reports are used.
- You may want to do the assignment as a group activity using the story of Bryan Cundiff or one of the Supplement 6 accident reports.
- Consider having students role-play those involved in accidents so that they may be interviewed.
- Have students complete Activity Sheet 1.

EVALUATION

- Give written test.
- Give practical tests, and evaluate test on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- *Accident Prevention Manual for Industrial Operations,* 7th ed. Chicago, Illinois: National Safety Council, 1974.
- *An Accident Prevention Program for School, Shops, and Laboratories.* State College, Pennsylvania: Department of Vocational Education/Pennsylvania State University, 1967.
- Carlson, Gene P., and William J. Vandervort, eds. *Essentials of Fire Fighting,* 2nd ed. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University, 1983.
- *Federal Register.* Vol. 36, No. 105. Pt. 2. Washington, D.C.: United States Department of Labor, 29 May 1971.
- *Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business.* Washington, D.C.: United States Environmental Protection Agency, 1986.

Media

- *Housekeeping Means Safe Keeping.* Color, 10 minutes, Journal Films, Inc., 1975. Available from Journal Films, Inc., 930 Pitner Avenue, Evanston, Illinois 60202. This film begins by taking the audience to a typical plant where they are presented with a variety of housekeeping violations. The dangers of these violations are then forcefully dramatized in the slow-motion recreation of a painful and realistic accident.
- *Stop a Fire Before It Starts.* Color, 10 minutes, Journal Films, Inc., 1975. Available from Journal Films, Inc., 930 Pitner Avenue, Evanston, Illinois 60202. In easy-to-understand laboratory demonstrations, this film shows how everyday materials become explosive in the presence of sparks, cigarettes, and so on. From the laboratory, the film moves to typical on-the-job locations where hazardous fire situations are encountered and their blazing conclusions displayed. Most importantly, viewers learn why these situations were hazardous and what could have been done to prevent these fires.
- *A New Way to Lift.* Color, 9 minutes, Journal Films, Inc., 1970. Available from Journal Films, Inc., 930 Pitner Avenue, Evanston, Illinois 60202. This film, produced in conjunction with the National Safety Council, demonstrates body mechanics that apply to all lifting situations. By following these tips, students may avoid serious back injury.
- *The Industrial Weightlifter II.* Color, 11 minutes, Ruddel Films for Industrial Accident Prevention Association, Ontario and Canada Packers, Ltd., 1981. Available from International Film Bureau, Inc., 332 South Michigan Avenue, Chicago, Illinois 60604. Visuals have been updated in this new version that illustrates correct techniques for lifting heavy objects to prevent injury.

- *How to Avoid 16 Leading Causes of OSHA Citations.* Color, 20 minutes, Bureau of Business Practice, 1978. Available from Bureau of Business Practice, 24 Rope Ferry Road, Waterford, Connecticut 06386. This film shows the most common OSHA violations and tells how to avoid them.

- *Safety in the Shop: Basic Practices.* Black and white, 13 minutes, Coronet Films, 1970. Available from Coronet Films, 65 East South Water Street, Chicago, Illinois 60601. This film emphasizes the worker's responsibility for safety in using hand and power tools. It explains the importance of a clean shop, proper clothing, and correct ways to guard against fires.

- *Danger Zone: Your Back.* Color, 18 minutes, Visucom Productions, 1981. Available from Visucom Productions, P.O. Box 5472, Redwood City, California 94063. This safety film demonstrates good lifting, pulling, and pushing practices and is designed to motivate employees to participate in accident prevention.

Print media

- *Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business.* Available free-of-charge from the United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. 20460.

  NOTE: This book outlines regulations that automotive shop operators should follow in the handling of hazardous wastes.

- Safety signs, posters, and other films or filmstrips

  NOTE: Various safety educational materials and filmstrips are available from Underwriters Laboratories, Inc., Public Information and Education Services, 207 East Ohio Street, Chicago, Illinois 60611.

- Full-color transparencies from the unit "Fire Behavior" in the International Fire Service Training Association (IFSTA) manual, *Essentials of Fire Fighting.*

  NOTE: This box of seventeen transparencies covering the burning process includes a plastic universal mount and an interleaf of each transparency for use by the instructor in a teaching outline. This set of transparencies is available from Fire Protection Publications, Oklahoma State University, Stillwater, Oklahoma 74078, or call toll-free 800-654-4055.

- Competency profiles, transparencies, and shop safety signs

NOTE: Competency profiles, transparencies, and shop safety signs for this book are available from the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.

INSTRUCTOR'S SUPPLEMENTS	LEARN AND APPLY GENERAL SAFETY PRACTICES
SUPPLEMENT 1	Safety Pledge

Safety Pledge

It is understood that each student/employee will be given proper instruction in the use of the equipment and in the correct safety procedures concerning the equipment before she or he will be allowed to operate it. The student/employee must assume responsibility for following safe practices. We, therefore, ask that the student/employee subscribe to the following safety pledge.

I will follow all safety rules.

I will never use a machine without first having permission from my instructor or supervisor.

I will not ask permission to use a particular machine unless I have been instructed in its use and have scored 100 percent on the safety test for that machine.

I will report immediately any accident or injury, no matter how minor, to my instructor or supervisor.

Student's/employee's signature_____ Date_____

Manager's signature_____ Date_____

Supervisor's or instructor's signature_____ Date_____

Parent's or guardian's signature_____ Date_____

(Parental consent is necessary if the student/employee is under 18.)

SUPPLEMENT 2

Safety Crossword Puzzle

Test yourself on safety terminology by using the clues below to complete the following crossword puzzle.

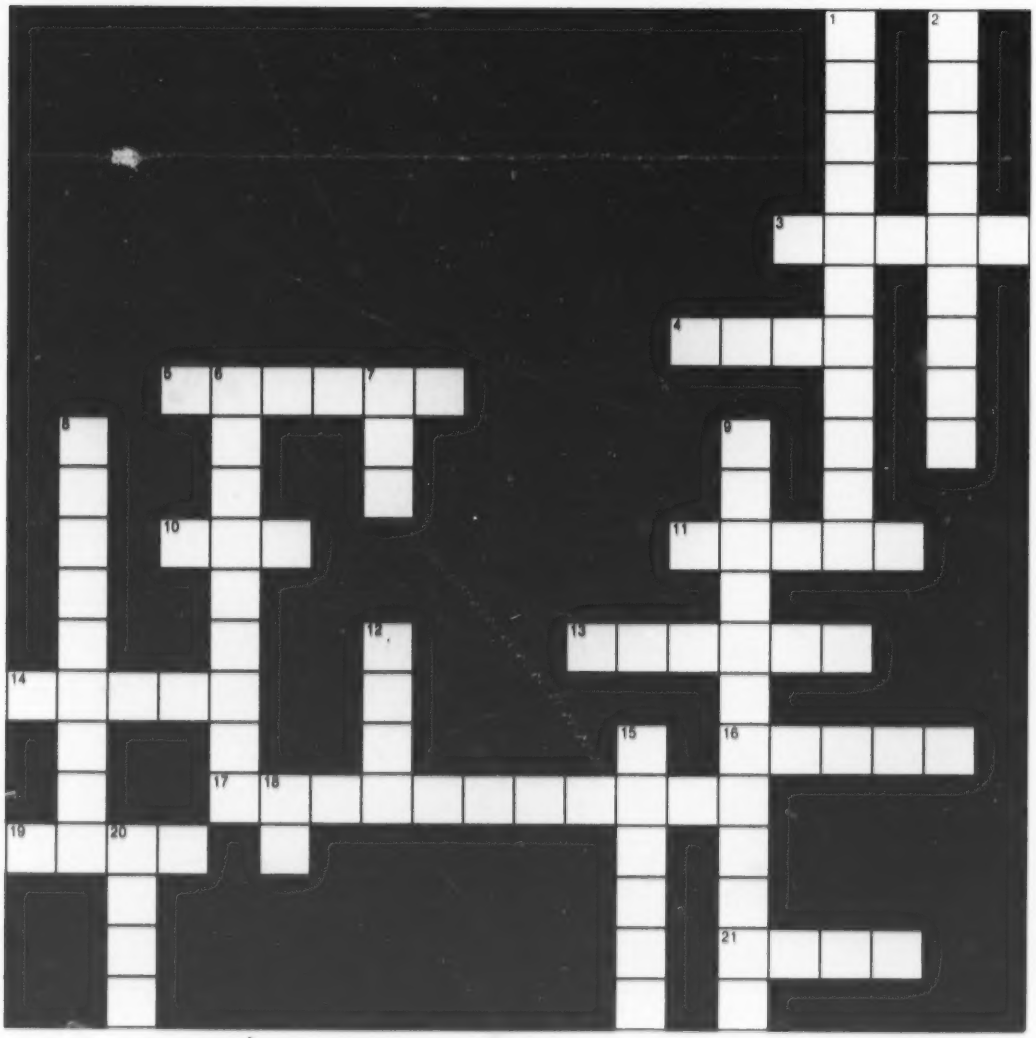
ACROSS

3. Guidelines
4. Inactivity after work or exertion
5. Source of danger
10. Flammable liquid
11. Federal safety color designating location of first-aid equipment
13. What all metal containers for flammable materials should be
14. Substance in fire extinguisher used on Class A and Class B fires
16. Indication of fire
17. Guidelines for job safety (2 wds.)
19. Group that works together toward a common goal
21. Free of danger; secure

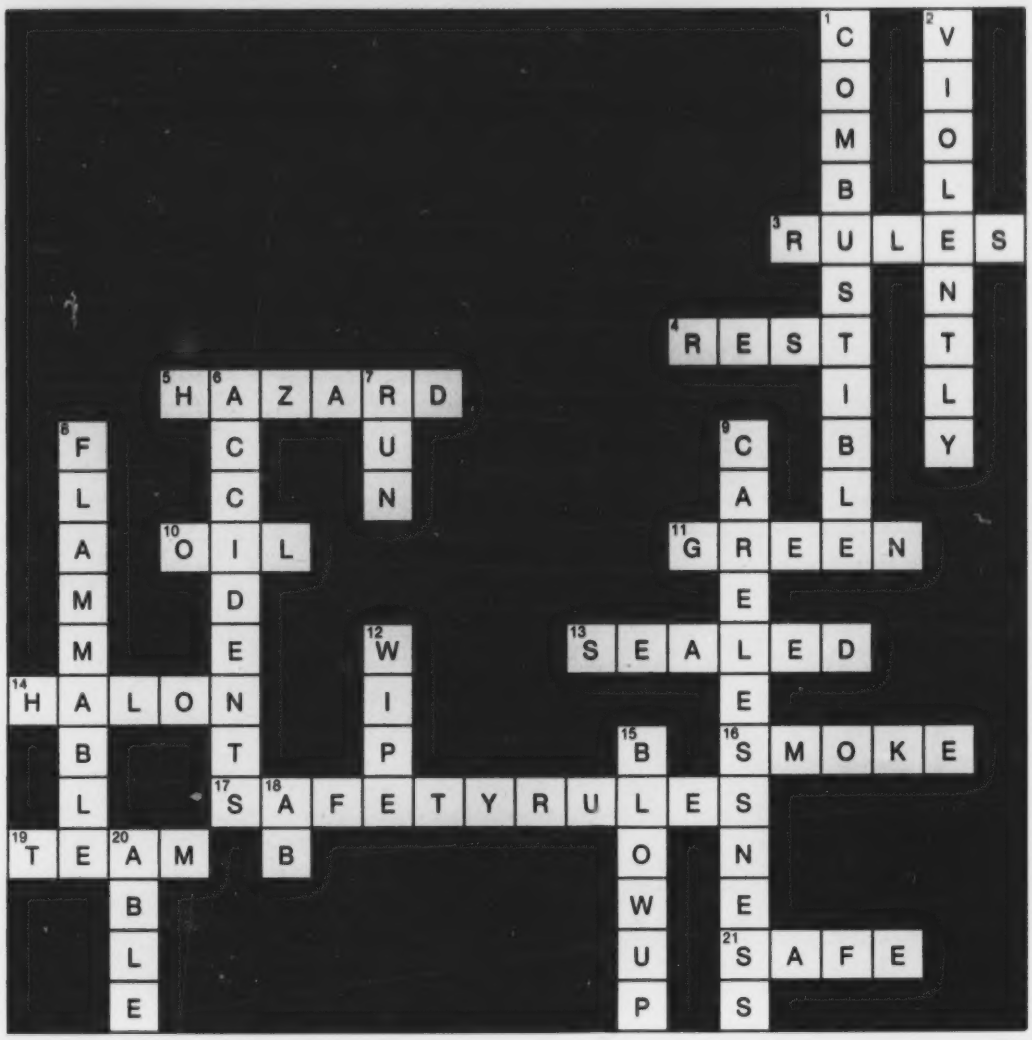
DOWN

1. Capable of bursting into flames
2. Explosively and loudly
6. Suddenly occurring unintentional events that cause injury or property damage
7. The worst thing to do if your clothing or hair catches fire
8. Capable of being easily ignited and burning quickly
9. Negligence; failure to think before one acts
12. _ _ _ _ up spills immediately
15. Explode; burst violently (2 wds.)
18. Fire extinguisher to use on flammable liquids and ordinary combustibles
20. Capable

Safety Crossword Puzzle



Answers to Safety Crossword Puzzle


1 C
2 V
O I
M O
B L
3 R U L E S
S N
4 R E S T T
5 H 6 A Z A 7 R D I L
8 F C U 9 C B Y
L C N A L
10 O I L 11 G R E E N
A E
M D
M E 12 W 13 S E A L E D
14 H A L O N I E
B T P 15 B 16 S M O K E
L 17 S 18 A F E T Y R U L E S
19 T E 20 A M B O N
B W E
L U 21 S A F E
E P S

INSTRUCTOR'S SUPPLEMENTS	***LEARN AND APPLY GENERAL SAFETY PRACTICES***
SUPPLEMENT 3	**How to Lift Safely**

The following safe practices should be observed in order to avoid injury.

The factors that contribute to safe lifting are...

WEIGHT
SIZE
SHAPE
DETERMINE IF OBJECTS CAN BE LIFTED AND CARRIED SAFELY.
1. Approach the load and size it up (weight, size and shape.) Consider your physical ability to handle the load.
2. Place the feet close to the object to be lifted 8 to 12 inches apart for good balance.
3. Bend the knees to the degree that is comfortable and get a good handhold. Then using both leg and back muscles . . .
4. Lift the load straight up—smoothly and evenly. Pushing with your legs, keep load close to your body.
5. Lift the object into carrying position, making no turning or twisting movements until the lift is completed.
6. Turn your body with changes of foot position after looking over your path of travel making sure it is clear.
7. Setting the load down is just as important as picking it up. Using leg and back muscles, comfortably lower load by bending your knees. When load is securely positioned, release your grip.
Stack material in such a manner as to permit full view while carrying.
When lifting and carrying with another person—teamwork is important. The load should be equally distributed. Movements must be coordinated so you both start and finish the lift action at the same time and perform turning movements together.
When two persons carry a long object, it should be held at the same level by both and on the same side of the body.
TEAMWORK
Avoid strain by storing heavy objects at least 12 inches above the floor.
Avoid awkward positions or twisting movements while lifting.
Over-reaching and stretching to reach overhead objects may result in strains or falls. Use a ladder instead of chairs, boxes, etc.

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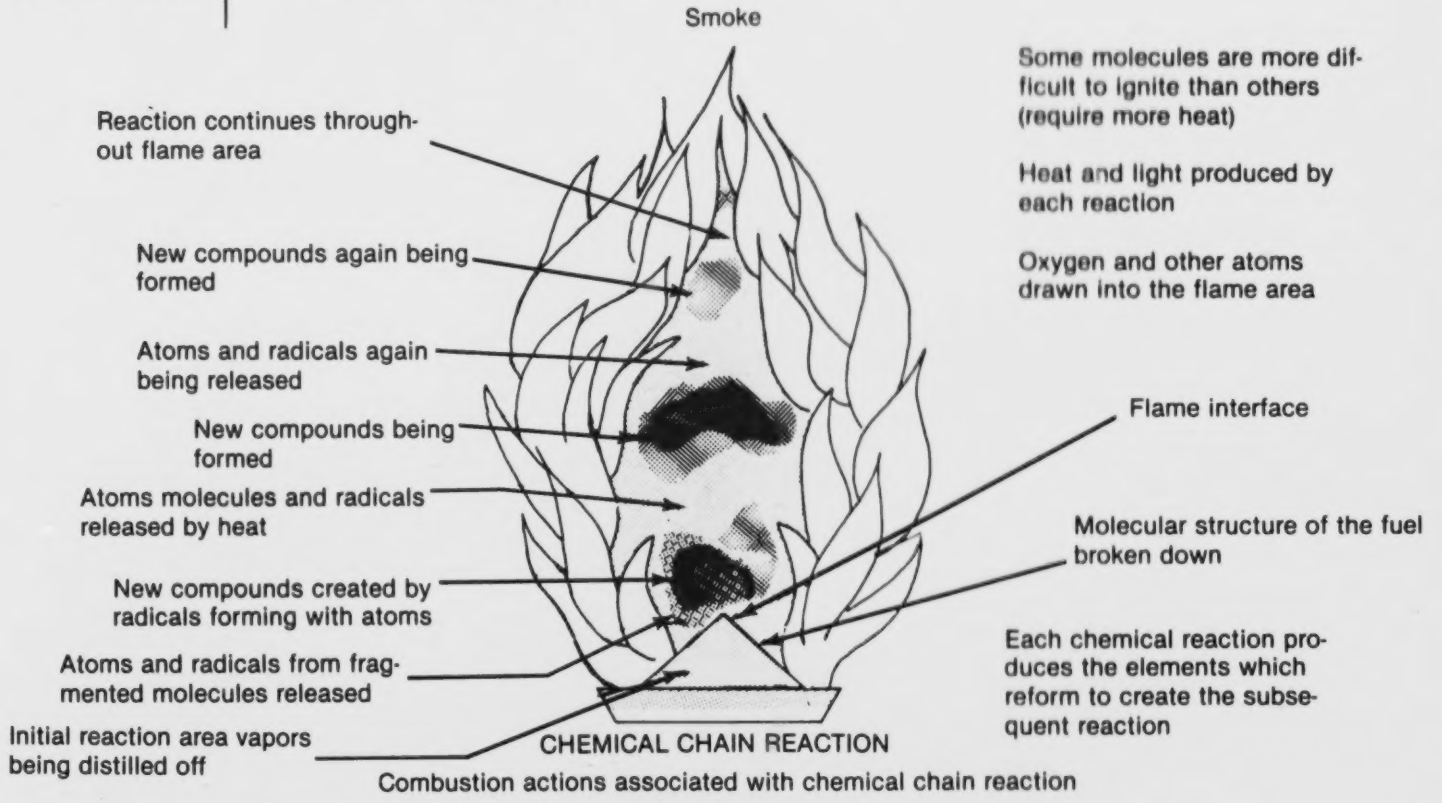
SUPPLEMENT 4 — Chemical Chain Reaction


Smoke
Some molecules are more difficult to ignite than others (require more heat)
Heat and light produced by each reaction
Oxygen and other atoms drawn into the flame area
Reaction continues throughout flame area
New compounds again being formed
Atoms and radicals again being released
New compounds being formed
Atoms molecules and radicals released by heat
New compounds created by radicals forming with atoms
Atoms and radicals from fragmented molecules released
Initial reaction area vapors being distilled off
Flame interface
Molecular structure of the fuel broken down
Each chemical reaction produces the elements which reform to create the subsequent reaction
CHEMICAL CHAIN REACTION
Combustion actions associated with chemical chain reaction

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SUPPLEMENT 5

Fire Extinguishment Theory

The extinguishment of a fire is based on the interruption of one or more of the essential elements in the combustion process. Generally, four methods may be used to extinguish fire.

Reduction of temperature — Fuel is cooled to the point where it does not produce sufficient vapor to burn; the most common cooling agent is water, which also converts to steam and smothers the fire

Removal of fuel — Flow of liquid or gaseous fuel is stopped, or solid fuel is removed from the path of the fire; fuel may also be allowed to burn until all fuel is consumed

Exclusion of oxygen — Oxygen concentration in the fire area is reduced, an inert gas is introduced, or oxygen is separated from the fuel

NOTE: This method of extinguishment does not work on self-oxidizing materials or on certain metals as they are oxidized by carbon dioxide or nitrogen—the two most common extinguishing agents.

Inhibition of chain reaction — Flame-producing chemical reaction is interrupted with the use of such extinguishing agents as dry chemicals or halons

NOTE: Chemical flame inhibition is effective only on gas or liquid fuels because they cannot burn in the smoldering mode of combustion. Carbon dioxide does not interrupt chemical reaction; it extinguishes by removing oxygen.

SUPPLEMENT 6

Activity Sheet 1 Accident Reports

NOTE: The following situations may be used with Activity Sheet 1, "Investigate an Accident," or for other discussions during the presentation of this unit.

CASE 1

Linda Parker, 27, was under a car checking a newly installed water pump for leaks when the radiator hose came off. The hot coolant spilled over her arms and upper body, causing second-degree burns. The shop manager examined the hose and clamp after the accident. The hose was in good shape, and there was no damage to the clamp. The shop manager stated that it appeared that the hose had not been tightened enough or the hose had not been slid fully onto the connection.

CASE 2

Jeff Makaloka, 23, was trying to remove a head bolt from an engine. The bolt would not turn. Jeff got the biggest socket-wrench handle he could find, and tried again. He climbed into the engine compartment and pulled as hard as he could. Jeff felt a sharp pain in his lower back. Jeff experienced painful back spasms for weeks and was treated for a collapsed disc in this back. Jeff said, "It just happened without any warning. I've never had any back trouble before. They showed us how to lift when I was in school, but nobody said anything about pushing and pulling."

CASE 3

Bobby Jacobi, 23, was going to replace some brake discs on a 1986 Buick Somerset. He placed a floor jack under the lower control arm on the driver's side, raised the car, and removed the wheel. As Bobby was disconnecting the caliper, the car fell on him, crushing his hand and arm. Some co-workers raised the car and pulled Bobby from under it. Their first-aid actions saved Bobby's life, but his hand was amputated at the hospital. Bobby said afterwards, "It was nearly closing time, and I figured if I hurried I could get the job done before quitting time. I guess I didn't really check the service manual, but I've done hundreds of brake jobs, and all those front-wheel-drive cars jack up the same. I don't know. Maybe I didn't get the jack under there straight."

SUPPLEMENT 7

Shop Readiness Test

Name _____ Score _____

INTRODUCTION

You must know the general safety rules commonly used in automotive shops in order to protect yourself and those you work with from accident. This test is designed to determine whether you know those rules.

NOTE: You must achieve a score of 100 on this test before you will be allowed to perform shop procedures of any nature.

DIRECTIONS

Read each of the following questions. Then choose the item that best answers each question. Write the letter of that item in the blank provided.

_____1. Which of the following is a general safety rule concerning proper shop conduct?

a. Be relaxed and conduct yourself in as professional a manner as possible
b. Be alert and conduct yourself in a safe manner
c. Continue horseplay only when the instructor's back is turned
d. Be impatient and impolite to fellow students

_____2. Whom do you report *all* accidents to, no matter how minor the accident may seem?

a. Your instructor
b. The school nurse
c. The school superintendent
d. Your lawyer

_____3. Which of the following rule(s) is **not** considered a shop dress safety rule?

a. Wear close-fitting clothing appropriate for the work being done
b. Confine long hair before using power equipment or working around moving parts
c. Wear safety goggles in the shop at all times
d. Carry tools and sharp objects in your pocket

_____4. Which of the following rules should be applied when you are operating lifting equipment?

a. Lift the vehicle slowly and check frequently to ensure proper balance
b. Lift the vehicle slowly and check for proper balance after reaching the desired height
c. Lift only the front or rear of the vehicle at a time
d. Check to see that the vehicle is supported properly after it has been lifted into position

_____5. Which of the following is **not** a proper use of compressed air?

a. Using compressed air to clean yourself or your clothing
b. Directing compressed air toward another person
c. Neither a nor b
d. Both a and b

_____6. Which of the following is **not** a safety rule pertaining to proper tool use?

a. Keep tools clean and in good working order
b. Properly store tools and equipment after use
c. Neither a nor b
d. Both a and b

_____7. Which of the following rules should be applied when you are operating equipment and tools in the shop?

a. Only obey those safety rules and operating instructions provided by your instructor
b. Only obey those safety rules and operating instructions provided by the equipment manufacturer
c. Only obey those safety rules and operating instructions posted near the tool or equipment
d. Obey all safety rules and operating instructions provided by the equipment manufacturer, plus any additional ones used for your shop

_____8. Which of the following rules should be followed if your hair or clothing should catch fire?

a. Scream "fire," run to a fellow worker, and drop and roll to allow him or her to smother the fire with a fender cover
b. Do **not** run; stop, drop, and roll to smother the fire, using a blanket or fender cover if available
c. Run to your instructor and have him or her spray water on you
d. None of the above

_____9. Which of the following rules should be applied when you are using tools and equipment that require guards or safety devices?

a. Use guards and safety devices only when the instructor is watching
b. Use guards and safety devices only when you are not wearing protective eyewear and clothing
c. Keep guards and safety devices in place on all equipment
d. Remove guards and safety devices only when the procedure you are performing requires their removal

_____10. Which of the following rules does **not** apply to the proper maintenance of a safe work area?

a. Store materials and supplies safely in their proper places
b. Arrange equipment and vehicles to allow safe working practices and ease of cleaning
c. Clear floor of obstacles and slippery substances and clean up spills at the end of each workday
d. Store tools and accessories safely in suitable storage containers or areas

_____11. Which of the following statements is the general safety rule regarding awareness in the shop?

a. Be aware of your work only; do not worry about the jobs others are performing around you
b. Be aware of where your instructor is so that you can practice safety when he or she is looking
c. Be aware of where others are in the shop and of what they are doing
d. None of the above

_____12. Which of the following statements pertains to proper dress in the shop?

a. Rings are allowed, but necklaces that might dangle into a vehicle's engine should be removed before you go into the shop
b. Jewelry may be worn in an automotive shop as long as you are not performing an automotive service procedure
c. Remove rings and other jewelry before going into the shop
d. Remove all jewelry just before using lifting equipment in the shop

_____13. Which of the following rules apply to proper shop dress?

a. Wear safety goggles in the shop at all times
b. Wear special safety equipment when required
c. Both a and b
d. Neither a nor b

_____14. Which of the following is the safety rule you should follow when you find that a tool, machine, or piece of equipment is defective?

a. Do not use the defective item; return it to the tool room immediately
b. Continue the service procedure but report the defect to your instructor as soon as possible
c. Leave the defective item as it is so that your instructor will not think you might have broken it
d. Tag the defective item and report it to your instructor

_____15. Which of the following statements apply when you are changing accessories or performing maintenance on power equipment?

a. Disconnect the equipment from the power source before performing the maintenance required
b. Remove the electrical junction plate before performing the maintenance required
c. Take off all guards before performing the maintenance required
d. All of the above

_____16. Which of the following rules should **not** be applied when you are starting a vehicle in the shop?

a. Be sure that an appropriate fire extinguisher is nearby
b. Warn other workers in the area, and clear workers from the engine area
c. Use a remote starter only when you are working under a vehicle
d. Avoid using a remote starter; start the vehicle with the ignition switch

_____17. Which of the following rules should be applied when you are moving a vehicle?

a. Use extreme caution when moving a vehicle; check around the vehicle and the planned path to make sure there are no obstacles in the way
b. Use a spotter to help you maneuver or park a vehicle in a close area
c. Wear your safety belt whenever you ride in or drive a vehicle, including test drives—no matter how short
d. All of the above

_____18. Which of the following statements is the first thing you should do before using any flammable material or toxic substance?

a. Ask whether or not any fellow worker has ever used the material or substance and then carefully follow their instructions for use
b. Put on rubber gloves if you know the material or substance contains acid
c. Assume that your instructor will give you any instructions for use that will be important to your safety
d. Carefully read and follow label directions for flammable liquids and toxic substances

_____19. Which of the following rules should **not** be applied when you are working with flammable materials or toxic substances?

a. Use flammable liquids and toxic substances only for their intended purposes
b. Be extremely careful when using a flammable liquid or toxic substance near a fire or flame
c. Have at work area only the amount of flammable liquid or toxic substance needed for the job being done
d. Avoid breathing fumes from flammable liquids and toxic substances

_____20. Which of the following safety rules should be applied when you are working with a vehicle's battery?

a. Do not allow tools or other metal objects to contact both battery terminals at the same time
b. Wear gloves and protective clothing when handling battery
c. Both a and b
d. Neither a nor b

_____21. Which of the following is **not** a safety rule for handling gasoline in the shop?

a. Be extremely careful when using gasoline near a fire or flame
b. Do not pour gasoline into a carburetor or onto a cylinder head when starting or running an engine
c. Never put fuel into a fuel tank when the engine is running
d. Do not operate a vehicle with a fuel leak

_____22. While working on a running front-wheel-drive vehicle, a student dropped a socket on the water pump. The student's hand was burned and her sleeve was caught in the moving belts. What safety rule(s) was **not** followed in this situation?

a. Be careful of moving parts on a vehicle, such as belts and fans
b. Avoid using sockets when working on engines
c. Both a and b
d. Neither a nor b

_____23. After completing a transmission overhaul, a student was on his way to pour the used transmission fluid into a trash can when he spilled a portion of the fluid on the floor. As the student walked back to his work station after pouring the fluid in the trash can, he slipped and fell on the fluid that had been spilled. What safety rule(s) was **not** followed in this situation?

a. Clear floors of obstacles and slippery substances; clean up spills immediately
b. Dispose of combustible materials properly
c. Both a and b
d. Neither a nor b

_____24. While a student worked on a running vehicle, the carburetor ignited. The student lost time in locating a fire extinguisher and as a result she was not able to save valuable parts from the fire. What safety rule(s) was **not** followed in this situation?

a. Do not work on a running vehicle
b. Be familiar with the location of fire-fighting and first-aid equipment
c. Both a and b
d. Neither a nor b

_____25. Which of the following is the golden rule that applies to each tool, machine, or piece of equipment you may operate in the shop?

a. Operate equipment only after receiving training on how to use it properly and safely
b. Operate equipment only when you are accompanied by the instructor
c. Operate equipment only after your lab partner has demonstrated how he or she uses it
d. Operate equipment at your own risk

SUPPLEMENT 8

Answer Key to Shop Readiness Test

1. b
2. a
3. d
4. a
5. d

6. c
7. d
8. b
9. c
10. c

11. c
12. c
13. c
14. d
15. a

16. c
17. d
18. d
19. b
20. c

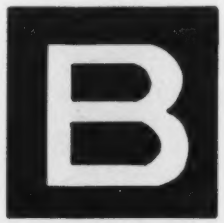
21. a
22. a
23. c
24. b
25. a

Types of Fire Extinguishers

KIND OF FIRE		APPROVED TYPE OF EXTINGUISHER					
		MATCH UP PROPER EXTINGUISHER WITH CLASS OF FIRE SHOWN AT LEFT Important: Using the wrong type extinguisher for the fire may be dangerous					
DECIDE THE CLASS OF FIRE YOU ARE FIGHTING...	THEN CHECK THE COLUMNS TO THE RIGHT OF THAT CLASS	CARBON DIOXIDE Carbon Dioxide Gas Under Pressure	PUMP TANK Plain Water	MULTI-PURPOSE DRY CHEMICAL	ORDINARY DRY CHEMICAL	HALON	DRY POWDER
CLASS A FIRES Use These Extinguishers ORDINARY COMBUSTIBLES ●Wood ●Paper ●Cloth, etc.							
CLASS B FIRES Use These Extinguishers FLAMMABLE LIQUIDS, GREASE ●Gasoline ●Paints ●Oils, etc.							
CLASS C FIRES Use These Extinguishers ELECTRICAL EQUIPMENT ●Motors ●Switches, etc.							
CLASS D FIRES Use This Extinguisher COMBUSTIBLE METALS ●Iron ●Magnesium							

Adapted with permission of American Association for Vocational Instructional Materials, Athens, Georgia, from *Developing Shop Safety Skills* by Clinton O. Jacobs and J. Howard Turner, 1981.

Standard Letter Symbols for Fire Extinguishers

GREEN	RED	BLUE	YELLOW
			
ORDINARY COMBUSTIBLES	FLAMMABLE LIQUIDS	ELECTRICAL EQUIPMENT	COMBUSTIBLE METALS

Distinctive letters, shapes, and colors mark extinguishers according to the classes of fires on which they should be used.

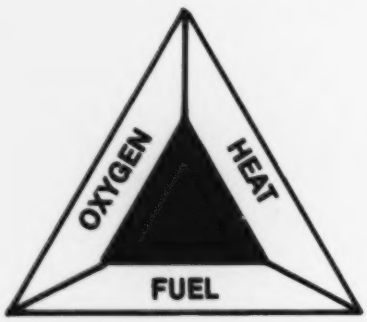
New Pictorial Symbols Used to Label Fire Extinguishers

Symbols with blue backgrounds indicate fire extinguisher can be used for class of fire portrayed.

Symbols with red line across a black background indicate fire extinguisher *cannot* be used for class of fire portrayed.

Fire Extinguisher Suitable for Class B and Class C Fires

Fire Triangle



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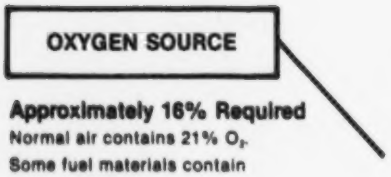

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To Reach Ignition Temperature

Open Flame — The Sun
Hot Surfaces
Sparks and Arcs
Friction — Chemical Action
Electrical Energy
Compression of Gases

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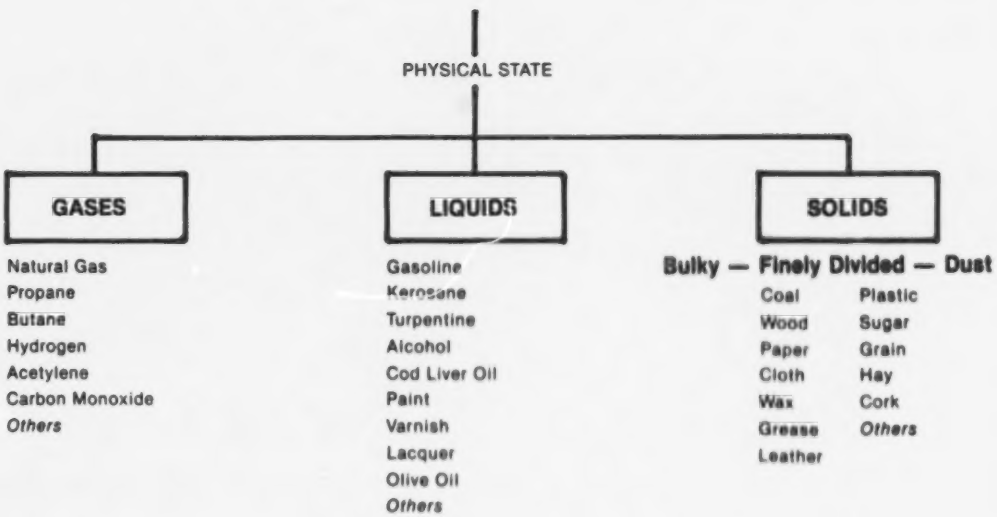

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PRETEST ANSWERS

LEARN AND APPLY GENERAL SAFETY PRACTICES

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	12
2	1, 2, 3, 4, 11, 13, 14, 15
3	19, 20, 21
4	8
5	22
6	9, 23
7	10, 24, 25
8	5, 16, 17
9	7
10	6, 18

ANSWER KEY

1. b
2. a
3. d
4. a
5. d
6. c
7. c
8. c
9. b
10. c
11. b
12. c
13. a
14. a
15. d
16. b
17. c
18. d
19. a
20. a
21. b
22. b
23. b
24. c
25. d

PRETEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

Name _____ Score _____

DIRECTIONS Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which accidents should be reported to your instructor?

   a. Only accidents resulting in personal injury
   b. All accidents
   c. Only accidents resulting in equipment or vehicle damage
   d. Only accidents that require a student to leave the shop for medical help

2. Spills in the shop should be cleaned up

   a. Immediately
   b. As time permits unless spill is in a walkway
   c. At the end of the day
   d. As time permits unless a really slippery substance like oil has been spilled

3. If your clothing catches fire, you should

   a. Remove it immediately
   b. Run to the nearest fire extinguisher
   c. Run to the nearest source of water because fire extinguishers should not be sprayed on a person
   d. Stop, drop to the ground, and roll to smother the flames

4. Vehicles that are running in the shop present what kinds of dangers?

   a. Dangers from moving parts, hot parts, and toxic gases
   b. Dangers from radiation
   c. Both a and b
   d. Neither a nor b

5. Emergency stop buttons for power equipment are what color?

   a. Yellow
   b. Green
   c. Orange
   d. Red

6. A fire involving electrical equipment such as a smoldering motor on an air compressor is what class of fire?

   a. Class A
   b. Class B
   c. Class C
   d. Class D

7. When raising a vehicle with a lift, the vehicle should be positioned so that it is supported at

   a. The vehicle's center of gravity
   b. A location recommended by the lift manufacturer
   c. A location recommended by the vehicle manufacturer
   d. None of the above; lifts should not be used in the shop

8. When lifting a heavy object, you should

   a. Extend your elbows out to lessen the direct strain on your shoulders
   b. Spread your feet far apart to distribute the weight as you lift with your legs and slowly bring your feet together
   c. Keep your back straight and your body weight directly over your feet as you stand up
   d. Hold the load close to your body by bending your shoulders and chest forward

9. Toxic substances in the automotive service shop may enter your body by

   a. Being breathed in only
   b. Being breathed in, swallowed, or absorbed through the skin
   c. Being absorbed through open wounds only
   d. Neither a nor b

10. Exhaust-removal equipment is required to be hooked up to a vehicle in the shop

    a. Any time a vehicle has a faulty exhaust system
    b. Only when you can see and smell the smoke coming from the vehicle's tail pipe
    c. Any time you are working on a vehicle and the engine is running
    d. Both a and b

11. Which of the following is **not** a good safety rule to observe when working with tools and equipment?

    a. Use the correct tool for the job to be done
    b. Be careful when using defective tools and equipment
    c. Keep guards and safety devices in place on all equipment
    d. Disconnect power equipment from power source before changing accessories or performing maintenance on it

12. A good definition of a *flammable* material is

    a. Something that is on fire and burning
    b. Something that is capable of bending easily and springing back into place
    c. Something that is capable of being easily ignited and burning quickly
    d. Something that is capable of putting out a fire

13. Which of the following is **not** a good safety rule for proper shop dress?

    a. Carry tools and sharp objects only in your pockets
    b. Put on close-fitting clothing that is appropriate for the work to be done
    c. Get any special safety equipment needed for the work to be done
    d. Remove rings and other jewelry

14. Which of the following is **not** a good safety rule for handling flammable liquids and toxic substances?

    a. When pouring gasoline into a carburetor with the engine running, use caution not to get the gasoline on hot parts such as exhaust manifolds
    b. Never use gasoline as a cleaner or solvent
    c. Do not operate a vehicle with a fuel leak
    d. Be sure that flammable liquids and toxic substances are properly marked and stored

15. Which of the following rules should be observed when starting a vehicle in the shop?

    a. Be sure the vehicle is out of gear
    b. Be sure that an appropriate fire extinguisher is nearby
    c. Be sure that no tools or obstacles that would interfere with starting or moving the vehicle are in the way
    d. All of the above

16. Waste containers for oily rags are painted

    a. Red
    b. Yellow
    c. Green
    d. Blue

17. The location of first-aid equipment should be marked with what color?

    a. Red
    b. Yellow
    c. Green
    d. Blue

18. A fire involving flammable liquids such as gasoline, oil, or solvent would require what type of fire extinguisher?

    a. Class C
    b. Class D
    c. Class A
    d. Class B

NOTE: Refer to the photograph on the following page to answer questions 19 through 21.

19. Which technician is dressed correctly?

    a. Neither is dressed correctly
    b. The one on the right
    c. The one on the left
    d. Both are dressed correctly

20. The technician holding the battery is violating what safety rule about handling batteries?

    a. She is not wearing gloves
    b. The vehicle is not properly grounded
    c. A battery should not be stored within 15 feet of a container of gasoline
    d. Her long hair is not confined

21. Which technician is obeying all safety rules about proper use of equipment and tools?

    a. Both
    b. Neither
    c. The one on the right
    d. The one on the left

22. Which of the following is **not** a safety rule for the use of frame or bumper jacks?

    a. Make sure that the transmission is in gear for manual transmissions and in PARK for automatic transmissions
    b. When working under a vehicle that is supported only by a jack, be very careful not to bump the jack
    c. Never try to raise the entire side of a vehicle with a jack
    d. Block the wheels opposite the side to be raised

23. Instructions for the use of toxic substances and the treatment for poisoning from them can normally be found

    a. In the first aid kit
    b. On the container label
    c. In vehicle manufacturers' service manuals
    d. All of the above

24. Carbon monoxide is a danger

    a. Only in small shops
    b. Only in shops without exhaust-removal equipment
    c. Any time a vehicle is running
    d. Only if gray, black, or bluish smoke is coming from a vehicle's tail pipe

25. A technician is working inside a vehicle, trying to adjust the heater. It is a cold day. The vehicle is parked inside a garage with the engine running. The vehicle windows are rolled up, and the heater is operating. The mechanic passes out after a few minutes. When you find him, his skin is bluish and feels slightly cool. What is the problem?

    a. Heat exhaustion
    b. Heat stroke
    c. Traumatic shock
    d. Carbon monoxide poisoning

INFORMATION SHEET	LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 1

Recognize definitions of terms associated with general safety practices

Safety — Freedom from danger, risk, or injury

Accident — Any suddenly occurring, unintentional event that causes injury or property damage

Hazard — Source of danger

Carelessness — Failure to think before one acts; failure to pay attention

Flammable — Capable of being easily ignited and burning quickly

NOTE: *Inflammable* means "flammable."

Combustible — Capable of bursting into flames

Extinguish — To put out a fire; to cause to cease burning

Corrosive — Tending to weaken or destroy, especially through chemical action

OBJECTIVE 2

Recall job safety rules

General

- Be alert and conduct yourself in a safe manner
- Be aware of where others are in the shop and of what they are doing
- Be familiar with the location of fire-fighting and first-aid equipment
- Report all accidents to your instructor, no matter how minor they may seem

One step more . . .

Examine your shop to locate all first-aid equipment. If you have questions about the use of anything in the first-aid kit or equipment such as eye wash stations, ask your instructor to explain their use to you. Also, locate fire extinguishers, hoses, alarms, and other such devices. Ask your instructor to explain fire evacuation routes and other emergency procedures.

Dress

- Wear close-fitting clothing appropriate for the work being done
- Wear safety goggles in the shop at all times
- Confine long hair before using power equipment or working around moving parts

  EXAMPLES: Running engines, moving belts, air wrenches, drive shafts

- Wear special safety equipment when required

  EXAMPLES: Welding goggles, apron, and gloves; ear protection; asbestos hood

- Remove rings and other jewelry before going into the shop
- Do **not** carry tools or sharp objects in your pockets

One step more . . .

Look yourself over, examining what you're wearing today. Ask yourself what you would have to change about your clothing in order to be dressed correctly for the shop. Look around the shop at some of the equipment used in the automotive repair trade. How would you have to dress differently to use the various types of equipment?

Equipment and tools

- Obey all safety rules and operating instructions provided by the equipment manufacturer, plus any additional ones used for your shop
- Keep tools clean and in good working order
- Properly store tools and equipment when not in use
- Keep guards and safety devices in place on all equipment
- Tag and report to the instructor any defective tools, machines, or equipment
- Turn off power equipment when not in use
- Operate equipment only after receiving training on how to use it properly and safely
- Disconnect power equipment from power source before changing accessories or performing maintenance on it
- Use the correct tool for the job to be done
- Correctly position lifting equipment and supports as required by the vehicle manufacturer
- Lift vehicles slowly and check frequently to ensure proper balance
- **Never** use compressed air to clean yourself or your clothing; do **not** direct compressed air toward another person

One step more . . .

Tools can be a technician's best friends. They save time and make work a lot easier—if they are used carefully and properly. Automotive repair requires the use of many specialty tools, perhaps more than any other trade. Each is designed to do a particular job, often on only one make and model of vehicle. But many technicians fail to use the correct tool, or they use the right tool but use it improperly. This leads to damaged tools or parts and more work to be done to fix the mess. Even more important, though, is the fact that damaged or improperly used tools can lead to someone's being hurt. Think of ways that you have seen tools used improperly: pliers used to remove or tighten nuts, screwdrivers used as chisels, wrenches used for hammers, the wrong size of wrench used. What others can you think of? What kinds of injuries can such misuse lead to?

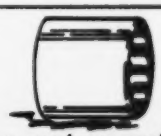
Work area

- Arrange equipment and vehicles to allow safe working practices and ease of cleaning
- Store materials and supplies safely in their proper places
- Store tools and accessories safely in suitable storage containers or areas
- Keep work area organized and clear of debris and other hazards
- Clear floors of obstacles and slippery substances; clean up spills immediately
- Keep aisles, exits, and traffic areas free of materials and debris
- Dispose of combustible materials properly

  EXAMPLES: Gasoline and solvents

- Keep enough brooms, brushes, waste containers, and housekeeping supplies on hand to keep the work area clean

The Story of Bryan Cundiff



Bryan Cundiff was always a hard-working and conscientious technician. He knew his trade and was good at what he did. He tried very hard to give an honest day's work to his employer. He kept his tools in good condition and his work area tidy. One day, Bryan was replacing the power-steering pump on a car. He had finished with one socket and was switching to another one when he dropped the first socket. It fell to the floor and rolled toward Bryan's tool cabinet. "No problem," thought Bryan. "I'll just pick it up when I go back to my cabinet for another tool. No use wasting time doing that now." So Bryan went on with the job. A few minutes later, Bryan needed a wrench. As he stepped toward his tool cabinet, his foot went down on the socket, which rolled out from under him, and Bryan fell to the floor. The fall injured his back, and he missed five weeks of work. Although insurance and worker's compensation helped, Bryan suffered a lot of pain, and his budget was hurt enough so that he had to put off buying the sports car he wanted. Was Bryan's mistake that he forgot about the socket? What if he hadn't forgotten it but, before he picked it up, another technician or the shop manager had come by and stepped on it?

Flammable materials and toxic substances

- Carefully read and follow label directions for flammable liquids and toxic substances; use only in well-ventilated areas
- Avoid breathing fumes from flammable liquids and toxic substances
- Be sure that flammable liquids and toxic substances are properly marked and stored

  NOTE: Keep flammable liquids and toxic substances in their original containers or in properly marked, approved containers.
- Have at work area only the amount of flammable liquid or toxic substance needed for the job being done
- Immediately change clothing on which flammable materials have been spilled
- Use flammable liquids and toxic substances only for their intended purposes

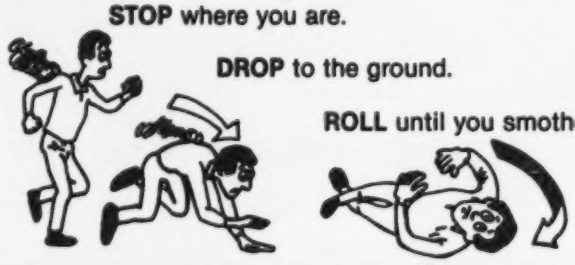
  EXAMPLE: Never use gasoline as a cleaner or solvent.
- If your hair or clothing catches fire, do **not** run; stop, drop, and roll to smother the fire, using a blanket or fender cover if available

If your clothes catch fire, *don't run*.

STOP where you are.

DROP to the ground.

ROLL until you smother the flames.



- Do **not** use flammable materials near a fire or flame
- Do **not** pour gasoline into a carburetor or onto a cylinder head when starting or running an engine
- **Never** put fuel into a fuel tank when the engine is running
- Do **not** operate a vehicle with a fuel leak

One step more . . .

Check around your shop to see how many flammable materials and toxic substances are present. Read the labels on these containers to see how the materials are supposed to be handled and stored. What dangers do the labels describe? Did you notice any other safety hazards as you looked around the shop?

Vehicles

- Be sure that a vehicle is out of gear before starting it
- Be sure that an appropriate fire extinguisher is nearby when starting or running a vehicle in the shop
- Use extreme caution when moving a vehicle in the shop; check around the vehicle and the planned path to make sure there are no obstacles in the way
- Use a spotter to help you if trying to maneuver or park a vehicle in a close area
- Do **not** leave a vehicle running in the shop without adequate exhaust-removal equipment in place
- Be careful of moving parts on the vehicle, such as belts and fans

  NOTE: Remember that many vehicles have electrically operated fans that can run any time the switch is on, even if the engine is not running.

CO

Carbon monoxide (CO) is a poisonous gas given off by automotive engines. You can't see it and you can't smell it, but it can kill you in a very short time. In fact, an engine running in a one-car garage can produce enough carbon monoxide to fill the building with a fatal amount of gas in just three minutes. CO is just one of the poisonous gases in the automotive repair shop. If you feel sleepy or dizzy or sick at your stomach or if your vision gets blurry or you have trouble breathing while working in an enclosed area, go outside and get some fresh air. These are signs that you may be breathing toxic gases.

- Be careful of parts that heat up during engine operation

  EXAMPLES: Exhaust pipes and manifolds, coolant hoses
- Do **not** allow tools or other metal objects to contact both battery terminals at the same time

  NOTE: Battery safety will be covered in more detail in Unit A-5, "Study Automotive Design."
- Wear gloves and protective clothing when handling batteries
- Wear your safety belt whenever you ride in or drive a vehicle, including test drives—no matter how short
- Avoid using remote starters; start the vehicle with the ignition switch to ensure proper control
- Warn other workers in the area and clear workers from the engine area when starting a vehicle

OBJECTIVE 8

Determine colors used in the safety color code

Federal safety red

- Indicates danger
- Identifies fire-protection equipment and its location
- Identifies portable containers of flammable liquids
- Identifies emergency stop bars, stop buttons, and electrical stop switches on machinery

Federal safety yellow

- Indicates caution and marks physical hazards

  EXAMPLES: Low beams, steps, pits

- Indicates waste containers for explosive or combustible materials
- Indicates equipment that should **not** be started, used, or moved

  EXAMPLES: Defective equipment, equipment being serviced

- Identifies the starting point or power source for machinery

One step more . . .

The federal safety color code system was put into effect so that dangers and safety equipment could be easily identified by anyone familiar with the code even if they see the colors in a place where they have never been before. Sometimes the colors are used in combination with each other. Look around your shop to see how many of the safety colors are in use. What color are the fire extinguishers? The first aid kit? Are the floors marked with any colors? Check other areas in your training facility for the use of the safety color code. For example, if nursing training is conducted in your school, do they have any areas marked with federal safety purple?

Federal safety orange

- Identifies dangerous parts of equipment that could cut, crush, shock, or otherwise injure
- Indicates safety starter buttons

Federal safety purple (or magenta or black on safety yellow)

- Indicates radiation hazards

Federal safety blue

- Identifies tags that indicate equipment that should **not** be started, used, or moved

  EXAMPLES: Defective equipment, equipment being serviced

Federal safety green

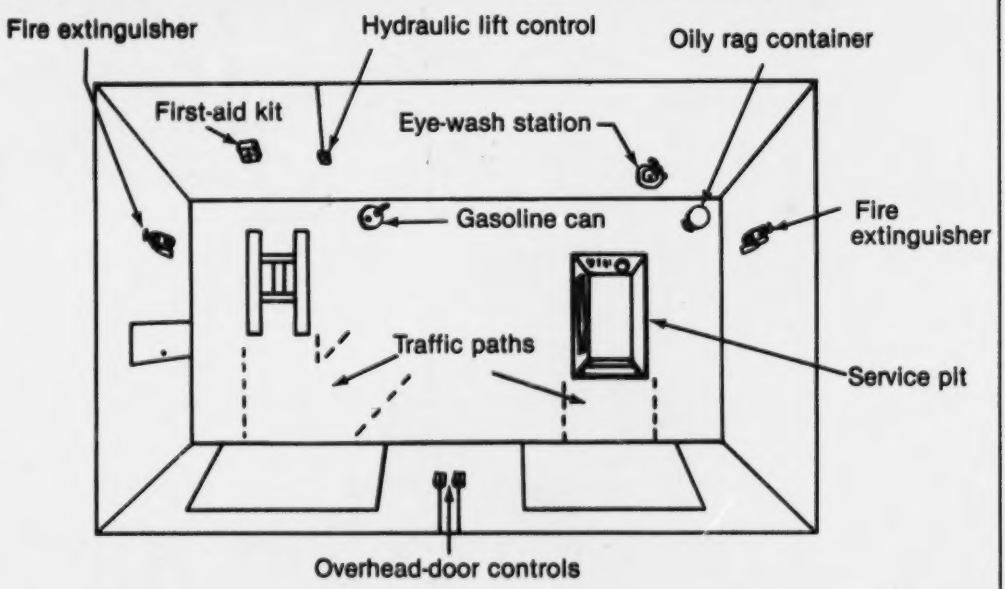
- Identifies safety equipment other than fire-fighting equipment and its location
- Identifies first-aid equipment and its location

Federal safety black and white

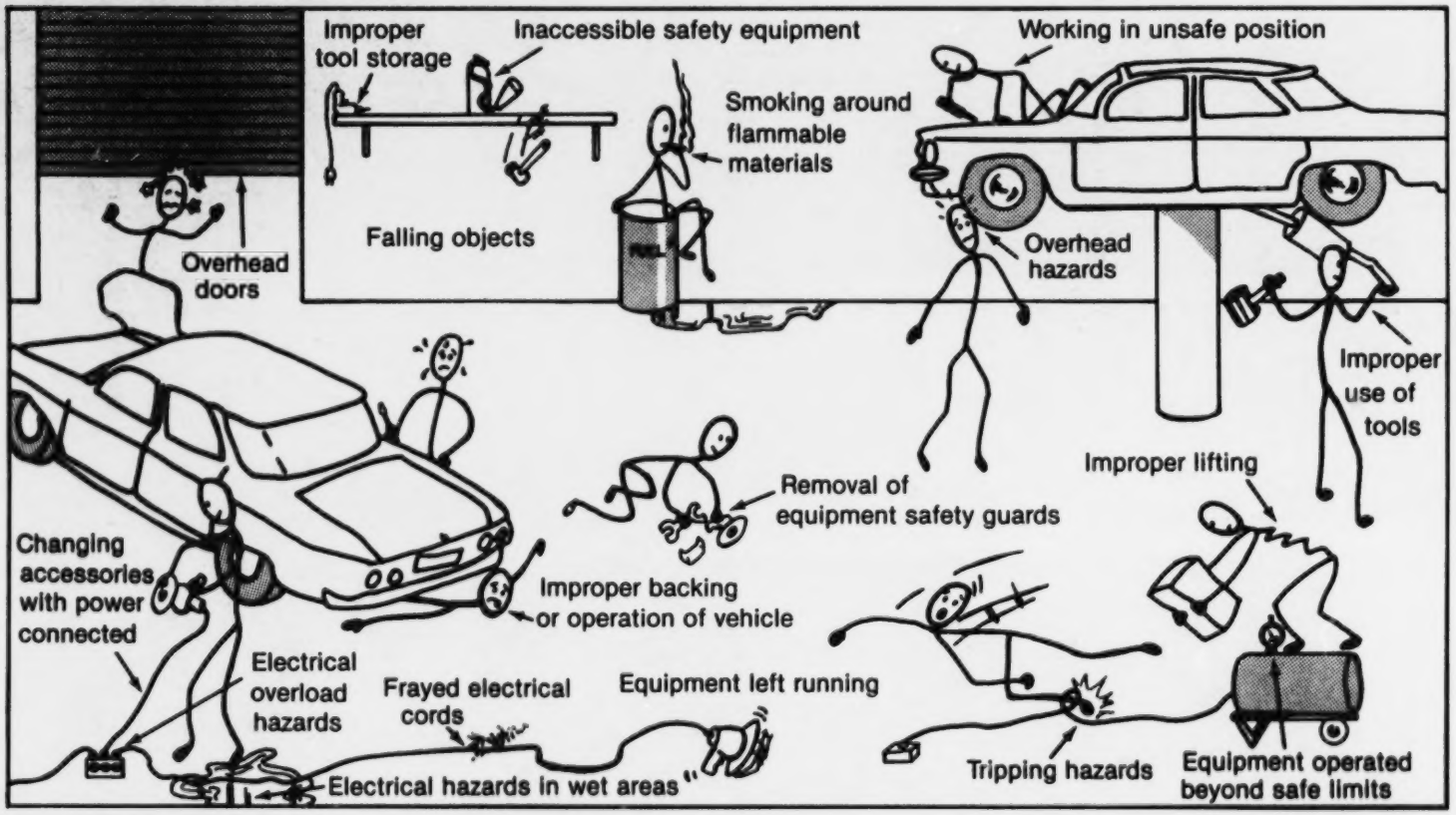
- Indicate traffic flow paths
- Indicate storage areas
- Identify housekeeping equipment and its location

One step more . . .

Look at the drawing below of a small automotive repair shop. A number of items that require federal safety color coding are labeled. Indicate what color the items should be either by writing in the correct color or by coloring it as it should be coded.



STUDENT SUPPLEMENTS	LEARN AND APPLY GENERAL SAFETY PRACTICES
SUPPLEMENT 1	Auto Repair Shop Safety Hazards



SUPPLEMENT 2

Classes of Fires

Fires are classified into four categories, depending on the substance that is burning. The reasons for classifying fires is that each class of fire is different and must be fought in a different way. The four classes of fires are listed below.

Class A — Fires that occur in ordinary combustible materials such as paper, wood, rags, rubber, and plastics

Class B — Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and solvent

Class C — Fires that occur in or near electrical equipment such as motors, switchboards, computers, and electrical wiring

Class D — Fires that occur with combustible metals such as iron, magnesium, sodium, and potassium

One step more . . .

Fire extinguishers contain different kinds of materials that may or may not be suitable for use in putting out a given class of fire. There are laws that require fire extinguishers to be clearly marked as to what kinds of fires they can be used on. You are likely to find two types of labels in use. The older style of label shows a colored symbol and a letter for each type of fire for which the extinguisher is suitable. The newer labels have a pictorial representation of each class of fire (or at least A, B, and C) with a band across the picture of fire classes for which the extinguisher is not suitable.

Letters **Pictorial**

Now that you are familiar with fire extinguisher markings, check the fire extinguishers in your shop and classroom. For what fires are they suitable? Imagine some fires that may be likely to occur in your shop. Could you use the available fire extinguishers for the fires you have thought of? What if a carburetor bursts into flames or an air compressor motor starts smoking?

ASSIGNMENT SHEET 1

LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 3

Analyze shop situations for safety violations

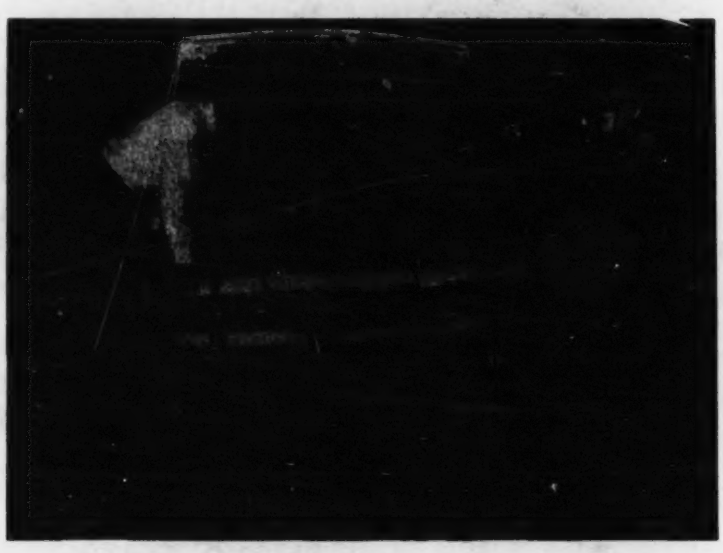
Name _____ Score _____

INTRODUCTION

A skilled automotive service specialist is constantly aware of threats to his or her safety and to the safety of others. The automotive repair profession requires the use of many dangerous tools and materials and requires work in areas where an accident is possible with even momentary carelessness. In order to prevent serious injury or even death, safe service specialists must always be on the lookout for dangerous situations in their work area and in the work of others around them.

DIRECTIONS

Study the photograph below, and note any hazardous situations or dangerous practices. List your observations on the lines below the photo. Use the back of this page if more space is required.



_____

_____

_____

_____

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ASSIGNMENT SHEET 2

LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 10

Determine the correct fire extinguisher to use for various classes of fires

Name _____ Score _____

INTRODUCTION

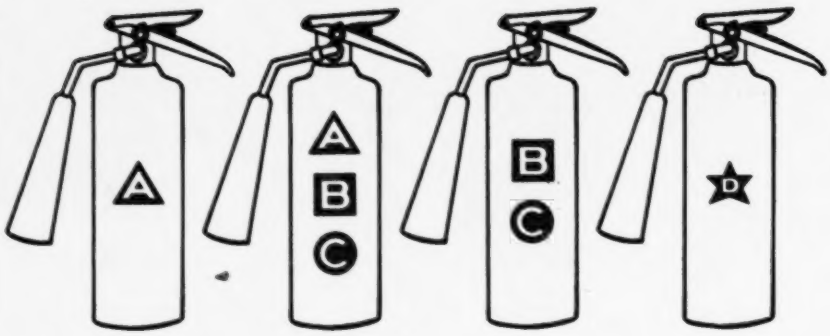
There are a great number of fire hazards in the auto repair shop. Just think about this: Most of the engines you will be working on are *internal combustion* designs, and *combustion* means "burning." Automotive engines operate by controlled explosions, and a little carelessness can allow the explosions to get out of control. Add to this the presence of electrical circuits and power tools; heating torches; flammable solvents, fluids, and oils; batteries; and the many other sources of fuel and heat for fires, and you will see how many different kinds of fires can start in the shop. For this reason, it is important that you be able to correctly respond to a fire.

The first step in determining the correct response is to determine the class of the fire you face. Review Student Supplement 2, "Classes of Fires," to help you understand how fires are classified.

In this assignment, you are presented with descriptions of several fires and are asked to select a fire extinguisher to use on the fire. As happens in real life, some of the fires may involve more than one class of fire. This is important for you to notice because the fire extinguisher you choose must be suitable for all the classes of fire involved. For example, if a pile of rags catches on fire because the rags are lying on a faulty electrical cord, you would not want to use a fire extinguisher that was suitable only for a Class A fire.

DIRECTIONS

Study the fire extinguishers shown on the next page. Read each of the situations given and choose the fire extinguisher or extinguishers that could be used to fight the fire. Write the number(s) of the fire extinguisher(s) that could be used on each fire in the blanks. Be sure to list each fire extinguisher that could be used.



1 2 3 4

_____1. Fire in a filing cabinet containing old invoices

_____2. Smoke coming from the electric motor of an air compressor

_____3. Fire caused by cigarette ashes dropping into a vat of solvent

_____4. Smoke coming from a barrel of oily rags

_____5. An electric hot plate left unattended in an office ignites papers on a bulletin board and spreads to wood paneling

_____6. Fire in an engine compartment that started because someone poured gasoline into a carburetor

_____7. Smoldering seat upholstery ignited by a cigar

_____8. Smoke coming from a battery charger

_____9. Puddle of spilled gasoline ignited by flames from a gas water heater

_____10. Smoke coming from a dash instrument panel

One step more . . .

Fire extinguishers are not always the best way to put out a fire. Sometimes they can actually make things worse or do more damage than the fire would have done if another method of extinguishing it had been used. There are times, too, when it is best not to try fighting the fire but is better to evacuate and summon professionals. Look back over the fires in this assignment. Which fires do you think would be better fought using something other than a fire extinguisher, and which would be better left to professional firefighters?

ASSIGNMENT ANSWERS

LEARN AND APPLY GENERAL SAFETY PRACTICES

ASSIGNMENT SHEET 1

A list of staged safety violations is given below. However, students may discover other valid safety violations. We recommend that you discuss this assignment in class or with individual students. The students' perceptions of what is wrong in the photo, whether correct or incorrect, will tell you a lot about their understanding of safety in the shop.

- Worker standing on creeper
- Worker's tie hanging into engine compartment
- Worker improperly handling battery
- Improperly stored gasoline
- Worker wearing jewelry
- Workers not wearing eye protection
- Worker standing on jack
- Jack not properly stored
- Troublelight not secured
- Electrical cord strung through work area
- Pneumatic hose strung through work area

ASSIGNMENT SHEET 2

1. 1, 2
2. 2, 3
3. 2, 3
4. 2, 3
5. 2
6. 2, 3
7. 1, 2
8. 2, 3
9. 2, 3
10. 2

ACTIVITY SHEET	LEARN AND APPLY GENERAL SAFETY PRACTICES

ACTIVITY SHEET 1

Investigate an accident

Name _____

INTRODUCTION

Even though workers may be careful, accidents do happen. Most companies conduct an investigation of any accidents that occur. The purpose of the investigation is not to try to lay the blame on someone. Accidents cost time, money, and lives, and so companies are interested in preventing accidents. Companies spend money on accident prevention programs and on conducting investigations.

In this activity, you will investigate an accident—either a real one or a simulated one—assigned to you by your instructor. During the investigation, you should ask yourself what happened, why it happened, and what could have been done to prevent the accident. The chart on the next page will help you to think of questions to ask. As a result of doing this investigation, you should have a better understanding of what causes accidents and what the experience is like for those involved.

DIRECTIONS

Study the chart on the next page and the accident report. You may also have the opportunity to interview people involved in the accident or people role-playing those involved. Complete the accident investigation form.

NOTE: The main objective of accident investigation is to determine the real cause of the accident and develop corrective action to prevent a reoccurrence. What really caused the accident? What can be done to prevent a similar accident from happening? The questions below will help you make these determinations.

Operating factors	Management controls	Questioning guide
PEOPLE		**Who was involved?**
	Placement	What qualifications are necessary to perform the task? Who is most qualified? Why was this employee selected if not most qualified?
	Training	What instructions or training were provided? What additional training is needed?
	Enforcement	What instructions or rules were not followed? What additional rules or enforcement action should be established?
EQUIPMENT		**What equipment was involved?**
	Design and arrangement	Why was this equipment used? What equipment should be used? What guards were or were not used? What arrangement problems were present? What additional design and arrangement controls are necessary?
	Purchasing	How did the quality or hazards of the equipment contribute to the loss? What additional purchasing controls are necessary?
	Maintenance	What maintenance problems were evident? When should maintenance be performed? How can maintenance be improved?
		What personal protective equipment is provided? When should personal protective equipment be used? What personal protective equipment should be provided?
MATERIAL		**What material (cargo) was involved?**
	Design and arrangement	What design characteristics contributed to the loss? How should the material be designed? How was the material arranged, handled, and used? How should the material be arranged, handled, and used? Where should the material be arranged?
	Purchasing	Why was this material being used? What material should be used?
ENVIRONMENT		**What environmental factors (building, noise, vapor, illumination, etc.) were involved?**
	Design and arrangement	Why was it designed and arranged this way? How should it be designed and arranged?
	Purchasing	What purchasing controls are necessary?
	Housekeeping	When should housekeeping be performed? How should housekeeping be improved?
	Maintenance	What maintenance problems are evident? When should maintenance be performed? How should maintenance be improved?

ACCIDENT INVESTIGATION

Company	Department		
Location	Date of Occurrence	Time ☐ AM ☐ PM	Date reported

PERSONAL INJURY

Name	
Occupation	Age
Nature of Injury	

DESCRIPTION	Describe clearly what took place, including the materials, equipment, and people involved.
ANALYSIS	Using the guide on the next page, describe each deficiency contributing to the loss.
PREVENTION	Describe in detail actions that have been or will be taken to prevent a recurrence. Be specific.

Investigated by	Date	Reviewed by	Date

Nature of Injury

Kind of Injury

Amputation
Burn (thermal, scald, chemical)
Contusion, crushing, bruise
Cut, laceration, puncture, open wound
Dislocation
Electric shock, electrocution
Foreign body (dust, rust, embedded)
Fracture
Heat stroke, sunstroke, heat exhaustion
Injuries, internal
Scratches, abrasions
Sprains, strains
Multiple injuries
Undetermined
Occupational disease (dermatitis, ganglion, etc.)
Other injury

Body part injured

Head (including face)
Eye
Arm
Wrists
Hands
Abdomen
Back
Chest
Hips
Shoulders
Neck
Knee
Leg
Foot
Multiple injuries

Deficiencies

Unsafe act

Cleaning, oiling, adjusting, or repairing of moving, energized, or pressurized equipment
Disregarded instructions or operating without authority
Failure to receive proper job instructions
Failure to use available personal protective equipment
Failure to secure or warn
Horseplay, quarreling or fighting
Improper use of equipment
Improper use of hands or body parts
Inattention to footing or surroundings
Making safety devices inoperative
Operating or working at unsafe speed
Using unsafe equipment
No unsafe act
Unclassified

Unsafe personal factor

Under influence of drugs/alcohol
Fatigue
Illness
Improper attitude
Lack of job knowledge or skill
Bodily defects
Act of other than injured
Undetermined
No unsafe personal factor
Other unsafe personal factor

Unsafe condition

Defective tools, equipment, substances
Dress or apparel hazard
Environmental hazards
Hazardous methods or procedures
Inadequately guarded
Improper illumination
Poor housekeeping
Undetermined
No hazardous condition

JOB SHEET 1

LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 4

Properly lift a heavy object

INTRODUCTION

One of the most painful and common injuries in any workplace is a back injury from using improper lifting techniques. Related injuries also occur as torn or strained muscles, ligaments, and joints in the neck, arms, or legs. Perhaps the saddest thing about such injuries, besides the fact that most could be easily avoided, is that most never heal completely. A back that has been injured once is likely to cause problems again even though the person is more careful than before. Some technicians try to show off by lifting objects that are too heavy or too awkward to be handled safely, while others are just embarrassed to ask for help. However, the truth is that no one is impressed when the show-off ends up in the hospital, and the embarrassment and inconvenience are much greater when co-workers must do the job of an injured worker.

The key to proper lifting is to hold your back straight while lifting with properly positioned legs. This procedure sheet outlines the proper way to lift a heavy object.

EQUIPMENT

- Heavy object

PROCEDURE

1. Step up to object; place one foot beside object and one behind (Figure 1)

FIGURE 1

2. Bend the knees and get a good handhold on the object (See Figure 2)

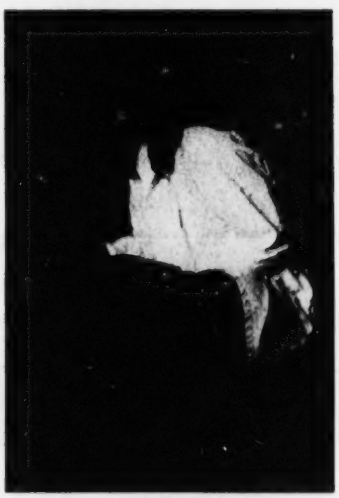
3. Tuck in chin (Figure 2)

FIGURE 2

4. Tuck in elbows and arms, and hold load close to body (See Figure 3)

5. Keeping back straight and body weight directly over feet, push with your legs as you stand straight up (Figure 3)

FIGURE 3



6. Lift the object into carrying position, making no turning or twisting movements until lift is completed (Figure 4)

FIGURE 4

7. Using leg and back muscles, comfortably lower load by bending your knees (Figure 5)

   NOTE: Setting the load down properly is just as important as picking the load up properly.

FIGURE 5

8. When load is securely positioned, release your grip

JOB SHEET 2	LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 5

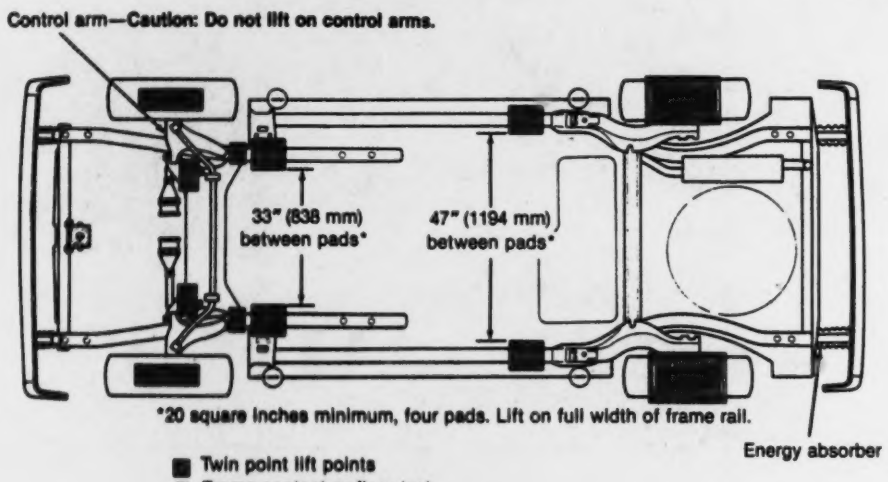
Raise a vehicle with a frame or bumper jack and place on jack stands

INTRODUCTION

Every year dozens of people are killed or seriously injured because improperly supported vehicles fall on them. To see how serious this problem is, choose a car in the shop or one of your own, and check to see how many sources of instructions there are on how to jack up the vehicle. Chances are you will find jacking instructions where the jack is stored, in the owner's manual, and in the service manual. Are such instructions also posted elsewhere on the car you chose? Perhaps on the jack itself or in the glove compartment? Along with those instructions, you will also find notes of caution about the use of jacks. Read and follow them carefully. As a minimum, use these guidelines:

- Position the proper jack as recommended by the vehicle manufacturer (see Figure 1). Be sure to use the proper location for the type of jack being used.

FIGURE 1


Control arm—Caution: Do not lift on control arms.
33" (838 mm) between pads*
47" (1194 mm) between pads*
*20 square inches minimum, four pads. Lift on full width of frame rail.
Energy absorber
Twin point lift points
Frame contact or floor jack
Drive on hoist
Scissors jack (emergency) locations

Lifting, jacking support locations

Used with permission of Chrysler Corporation.

- Place jack so that neither the jack nor its handle presents a hazard in aisles and traffic ways.

- Place jack on level, solid surface.
- Make sure manual transmissions are in gear and automatic transmissions are in PARK *with the brake set.*
- Block the wheels opposite the side to be raised.
- Never try to raise the entire side of a vehicle with a jack.
- Use the jack only to raise or lower the vehicle. Leave the vehicle on the jack only long enough to raise or lower it. If the vehicle must remain raised, support it with jack stands.
- Use jack stands adequate to support the vehicle, and make sure they are properly positioned.
- **Never** work under a vehicle that is supported only by a jack or jacks.

EQUIPMENT AND MATERIALS

- Various types of bumper, sill, and frame jacks
- Various vehicles
- Service manuals for vehicles used

PROCEDURE

NOTE: Your instructor will demonstrate the use of jacks available in your shop.

JOB SHEET 3	LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 6

Handle and store flammable materials and toxic substances

INTRODUCTION

Many of the materials used in the automotive repair shop are flammable or toxic. Toxic substances are poisons that can cause death or illness. They can enter the body in three different ways. They may be breathed in, such as carbon monoxide or asbestos particles. They can be swallowed, such as when trying to start to siphon gasoline or when wiping your hand across your mouth after handling a battery. And they can be absorbed through the skin, as with gasoline, sealants, solvents, battery acid, or other chemicals.

In addition to the guidelines described in the information sheet, you should read and carefully follow the directions on labels of flammable materials and toxic substances. Generally, these labels will provide instructions for handling and storing such materials. Also, a toxic substance label will usually explain first-aid procedures to follow if there is an accident involving the substance, such as swallowing the material or splashing it in your eyes. You should memorize these procedures for substances that you handle frequently, especially if they are likely to be used away from their original container or if the label is likely to become unreadable.

EQUIPMENT AND MATERIALS

As required for materials being handled or stored

PROCEDURE

NOTE: Your instructor will demonstrate handling and storage of such materials used in your shop.

JOB SHEET 4	LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 7

Operate exhaust-removal equipment

INTRODUCTION

The work that you will be doing in the automotive repair shop requires that vehicles be started and left running in the shop. Engine tune-up adjustments, procedures requiring engine speed or vacuum pressure checks, and other tasks can only be done with the engine running, and any time an internal combustion engine is running, it produces carbon monoxide (CO). Some people think carbon monoxide is dangerous only when they can see smoke coming from the tail pipe, but remember that CO is colorless and odorless. Any smoke you see or smell contains oil or steam in addition to CO and other gases. Whether visible or not, exhaust gases can quickly fill a shop, especially in a shop where several vehicles are idling, and kill everyone in it.

At first, a person suffering from carbon monoxide poisoning may feel dizzy or sick at the stomach. Blurring of the vision may occur. Eventually, the poisoning victim will become sleepy and will pass out from lack of oxygen. The person's skin will be bluish, especially around the lips and fingers. Body temperature will be normal or slightly cool. At this point, first-aid treatment is critically important. Lack of oxygen can quickly lead to brain damage. In a few minutes, the victim will cease breathing altogether and die. The best treatment is to prevent carbon monoxide poisoning by using exhaust-removal equipment.

Automotive repair shops are equipped with exhaust-removal equipment. These devices consist of a suction system and are vented out of the shop. Whenever you are working on a vehicle in the shop with the engine running, be sure to properly hook up and operate the exhaust-removal equipment. Also inspect the exhaust system of a vehicle before running it in the shop. If the exhaust system has holes, poor connections, a defective muffler or catalytic converter, or other problems, the majority of the exhaust and, thus, the carbon monoxide may not be coming out of the tail pipe. Such exhaust systems should be repaired before the vehicle is idled in the shop so that exhaust-removal equipment can be used to effectively remove CO.

EQUIPMENT AND MATERIALS

- Various vehicles
- Exhaust-removal equipment
- Operator's manual for exhaust-removal equipment

PROCEDURE

NOTE: Your instructor will demonstrate the use of exhaust-removal equipment in your shop.

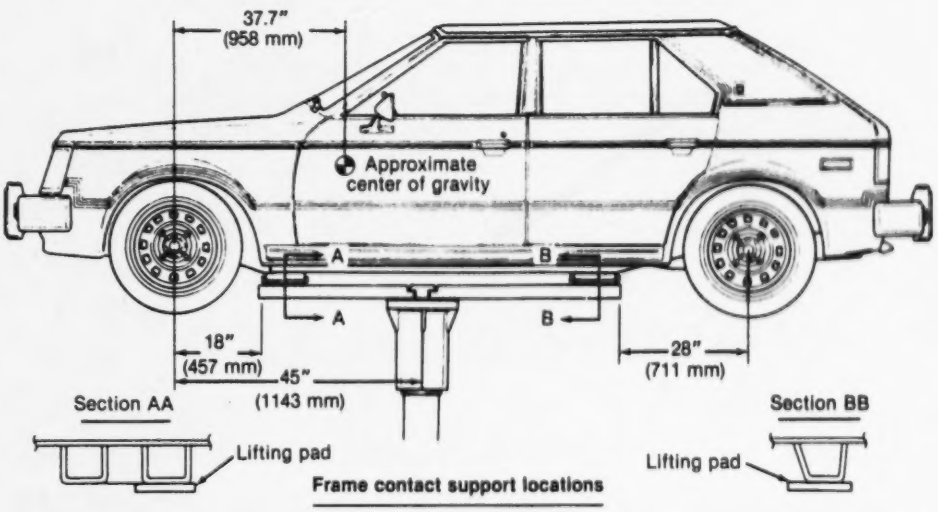
JOB SHEET 5	LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 9 — **Raise a vehicle on a hydraulic lift**

INTRODUCTION

A hydraulic lift is generally one of two types. One design has ramps onto which the vehicle is driven. The other type supports the vehicle at points on the frame. Each of these types has specific advantages and disadvantages depending on the job to be done, but each also has specific safety considerations. Manufacturers design vehicles so that there are correct locations for positioning lifts (see Figure 1). The locations are based on the balance of the vehicle and the strength requirements.

FIGURE 1



Used with permission of Chrysler Corporation.

Before raising a vehicle on a lift, you must make sure that it is balanced similarly to how it was designed to be balanced. Check to see that the vehicle is not overloaded, especially at any one point. Be sure that wheel and suspension systems are in good condition and not excessively out of alignment. Be especially careful about raising the vehicle into obstacles over the lift area.

Once the vehicle has been raised, it presents a whole new list of safety hazards. There is the danger of the vehicle falling and of parts falling from it. People may bump their heads when walking or standing up under it, or they may slip from fluids and oils that leak from it. Be especially aware of such possible hazards when working on a vehicle on a lift.

EQUIPMENT AND MATERIALS

- Various vehicles
- Service manuals for vehicles used
- Hydraulic lift
- Operator's manual for lift

PROCEDURE

NOTE: Your instructor will demonstrate the operation of hydraulic lift equipment in your shop.

PRACTICAL TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

JOB SHEET 1

Properly lift a heavy object

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Positioned him/herself in reference to object with one foot beside object and one foot behind.	____	____
2. Began lift by grasping load firmly and holding it close to body while keeping knees bent and chin, elbows, and arms tucked in.	____	____
3. Lifted object into carrying position by standing straight up while keeping back straight and body weight directly over feet.	____	____
4. Kept back straight and lowered load, using leg and back muscles properly.	____	____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

JOB SHEET 2

Raise a vehicle with a frame or bumper jack and place on jack stands

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Positioned jack on level, solid surface and as recommended by the vehicle manufacturer.	_____	_____
3. Prepared vehicle properly for lift.	_____	_____
4. Raised vehicle properly.	_____	_____
5. Supported vehicle properly with jack stands.	_____	_____
6. Lowered vehicle properly.	_____	_____
7. Returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

JOB SHEET 3

Handle and store flammable materials and toxic substances

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Read and carefully noted manufacturer's directions for handling and storing flammable or toxic substance.	____	____
2. Read and carefully noted first-aid procedures to follow in case of accident involving substance.	____	____
3. Obtained proper equipment and materials for handling substance during procedure.	____	____
4. Handled substance as noted during procedure.	____	____
5. Stored material as noted following procedure.	____	____
6. Cleaned work area and properly disposed of waste materials.	____	____

EVALUATOR'S COMMENTS

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

JOB SHEET 4

Operate exhaust-removal equipment

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected vehicle's exhaust system for holes, poor connections, or other problems.	_____	_____
3. Repaired exhaust-system problems if necessary.	_____	_____
4. Read and carefully noted manufacturer's instructions for hooking up and operating exhaust-removal equipment.	_____	_____
5. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

JOB SHEET 5

Raise a vehicle on a hydraulic lift

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected vehicle to be certain wheel and suspension systems are in good condition.	_____	_____
3. Followed vehicle manufacturer's specifications for positioning vehicle on lift.	_____	_____
4. Checked to be sure that vehicle would not be raised into obstacle over lift area.	_____	_____
5. Raised vehicle properly.	_____	_____
6. Lowered vehicle properly.	_____	_____
7. Returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST

LEARN AND APPLY GENERAL SAFETY PRACTICES

Name _____ Score _____

OBJECTIVE 1

Choose the definitions that best define the following terms associated with general safety practices. Write the correct numbers in the blanks.

_____a. **Safety**

1. Freedom from danger, risk, or injury
2. Source of danger
3. Device used to permit operation of another device

_____b. **Accident**

1. Any suddenly occurring, unintentional event that causes injury or property damage
2. Failure to think before one acts; failure to pay attention
3. Carefully controlled procedure performed to determine what will happen in a given situation

_____c. **Hazard**

1. Poison
2. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body
3. Source of danger

_____d. **Carelessness**

1. Any suddenly occurring, unintentional event that causes injury or property damage
2. Daydreaming
3. Failure to think before one acts; failure to pay attention

_____e. **Flammable**

1. Incapable of being easily ignited
2. Capable of being easily ignited and burning quickly
3. Capable of being easily quenched or smothered when burning

_____f. **Combustible**

1. Capable of bursting into flames
2. Capable of exploding
3. Capable of being a potential source of danger

_____g. **Extinguish**

1. To revive a person by bringing the person back to full consciousness
2. To be able to tell the difference between two similar objects
3. To put out a fire; to cause to cease burning

_____h. **Corrosive**

1. Tending to weaken or destroy, especially through chemical action
2. Capable of producing electricity
3. Medication applied to burns and other superficial wounds

OBJECTIVE 2

State job safety rules. For each word or phrase below, write a safety rule that goes with that word or phrase.

General

a. Conduct — _____

_____

_____

b. Other people in the work area — _____

_____

_____

c. Location of fire-fighting and first-aid equipment — _____

_____

_____

d. Reporting accidents — _____

_____

_____

Dress

a. Appropriate clothing — _____

_____

_____

b. Safety goggles — _____

_____

_____

c. Long hair — _____

_____

_____

d. Special safety equipment — _____

_____

_____

e. Jewelry — _____

_____

_____

f. Pockets — _____

_____

_____

Equipment and tools

a. Safety rules and operating instructions — _____

_____

_____

b. Working order — _____

_____

_____

c. Storage — _____

_____

_____

d. Guards and safety devices — _____

_____

_____

e. Defective tools — _____

_____

_____

f. Turning off power equipment — _____

_____

_____

g. Training — _____

_____

_____

h. Changing accessories — _____

_____

_____

i. Correct tool — _____

_____

_____

j. Lifting equipment — _____

_____

_____

k. Lifting vehicles — _____

_____

_____

l. Compressed air — _____

_____

_____

Work area

a. Arrangement of equipment and vehicles — _____

_____

_____

b. Storage of materials and supplies — _____

_____

_____

c. Storage of tools and accessories — _____

_____

_____

d. Work area — _____

_____

_____

e. Floors — _____

_____

_____

f. Aisles, exits, and traffic areas — _____

_____

_____

g. Combustible materials — _____

_____

_____

h. Housekeeping supplies — _____

_____

_____

Flammable materials and toxic substances

a. Label directions — _____

_____

_____

b. Fumes — _____

_____

_____

c. Storage — _____

_____

_____

d. Amount needed for the job — _____

_____

_____

e. Clothing — _____

_____

_____

f. Intended purposes — _____

_____

_____

g. Clothing that catches on fire — _____

_____

_____

h. Fire — _____

_____

_____

i. Carburetor — _____

_____

_____

j. Fuel tank — _____

_____

_____

k. Fuel leak — _____

_____

_____

Vehicles

a. Gear — _____

_____

_____

b. Fire extinguisher — _____

_____

_____

c. Moving a vehicle — _____

_____

_____

d. Spotter — _____

_____

_____

e. Exhaust removal — _____

_____

_____

f. Moving parts — _____

_____

_____

g. Heat — _____

_____

_____

h. Battery terminals — _____

_____

_____

i. Handling batteries — _____

_____

_____

j. Safety belts — _____

_____

_____

k. Control of vehicle when starting — _____

_____

_____

l. Other workers when starting a vehicle — _____

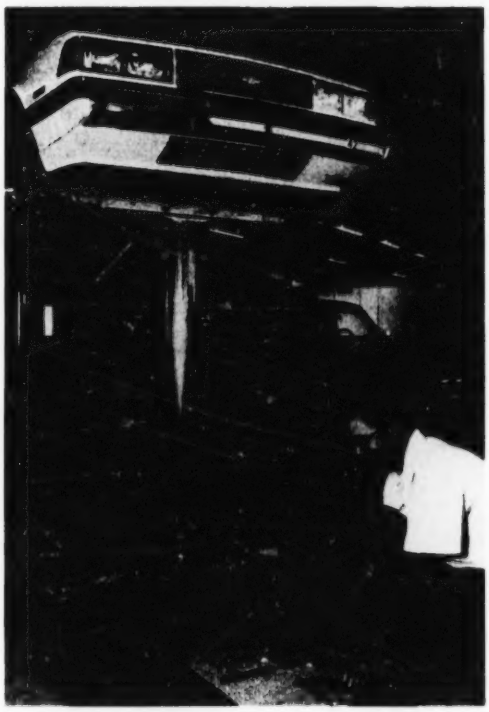
_____

_____

177

OBJECTIVE 3

Study the following photograph to see if any safety rules are being violated and list any violations below.



_____

_____

_____

_____

_____

OBJECTIVE 8

Several situations in which federal safety code colors are used are described below and on the next page. Read each situation, and answer the question that follows.

a. A fire ignites when a tank of diesel fuel spills. You need to find a fire extinguisher quickly. What color marking the location of the fire extinguisher should you look for?

_____

b. The hydraulic lift in your shop is going to be repaired. Your supervisor asks you to trip the circuit breaker for the lift and get a warning tag from the tool room to put on the circuit breaker. What color of tag should you look for?

_____

c. You are about to pull a car into the shop. What color of lines indicate the traffic-flow paths you should follow?

_____

d. A co-worker has splashed battery acid in her eyes and asks you to find the eye-wash station. What color marking the location of the eye-wash station should you look for?

_____

e. You have mopped up a kerosene spill and want to properly dispose of the rags you used. What color of waste container should you look for?

_____

OBJECTIVE 10

Choose the correct fire extinguisher for each fire described below. Write the number of that extinguisher beside the description.

_____a. A waste basket full of paper ignited by a cigarette

_____b. Smoke from an air compressor motor

_____c. A 5-gallon can of gasoline spills and ignites from the flame of a propane space heater

_____d. Smoke coming from a can of oily rags

_____e. Sparks from an electric grinder ignite a vat of kerosene

_____f. A fire starts when a technician pours gasoline in a carburetor

1

2

3

NOTE: Turn in your test to your instructor, who will grade the test and determine if additional training is needed.

WRITTEN TEST ANSWERS

LEARN AND APPLY GENERAL SAFETY PRACTICES

OBJECTIVE 1

a. 1
b. 1
c. 3
d. 3
e. 2
f. 1
g. 3
h. 1

OBJECTIVE 2

General

a. Be alert and conduct yourself in a safe manner
b. Be aware of where others are in the shop and of what they are doing
c. Be familiar with the location of fire-fighting and first-aid equipment
d. Report all accidents to your instructor, no matter how minor they may seem

Dress

a. Wear close-fitting clothing appropriate for the work being done
b. Wear safety goggles in the shop at all times
c. Confine long hair before using power equipment or working around moving parts
d. Wear special safety equipment when required
e. Remove rings and other jewelry before going into the shop
f. Do **not** carry tools or sharp objects in your pockets

Equipment and tools

a. Obey all safety rules and operating instructions provided by the equipment manufacturer, plus any additional ones used for your shop
b. Keep tools clean and in good working order
c. Properly store tools and equipment when not in use
d. Keep guards and safety devices in place on all equipment
e. Tag and report to the instructor any defective tools, machines, or equipment
f. Turn off power equipment when not in use
g. Operate equipment only after receiving training on how to use it properly and safely
h. Disconnect power equipment from power source before changing accessories or performing maintenance on it
i. Use the correct tool for the job to be done
j. Correctly position lifting equipment and supports as required by the vehicle manufacturer
k. Lift vehicles slowly and check frequently to ensure proper balance

l. Never use compressed air to clean yourself or your clothing; do **not** direct compressed air toward another person

Work area

a. Arrange equipment and vehicles to allow safe working practices and ease of cleaning
b. Store materials and supplies safely in their proper places
c. Store tools and accessories safely in suitable storage containers or areas
d. Keep work area organized and clear of debris and other hazards
e. Clear floors of obstacles and slippery substances; clean up spills immediately
f. Keep aisles, exits, and traffic areas free of materials and debris
g. Dispose of combustible materials properly
h. Keep enough brooms, brushes, waste containers, and housekeeping supplies on hand to keep the work area clean

Flammable materials and toxic substances

a. Carefully read and follow label directions for flammable liquids and toxic substances; use only in well-ventilated areas
b. Avoid breathing fumes from flammable liquids and toxic substances
c. Be sure that flammable liquids and toxic substances are properly marked and stored
d. Have at work area only the amount of flammable liquid or toxic substance needed for the job being done
e. Immediately change clothing on which flammable materials have been spilled
f. Use flammable liquids and toxic substances only for their intended purposes
g. If your hair or clothing catches fire, do **not** run; stop, drop, and roll to smother the fire, using a blanket or fender cover if available
h. Do **not** use flammable materials near a fire or flame
i. Do **not** pour gasoline into a carburetor or onto a cylinder head when starting or running an engine
j. **Never** put fuel into a fuel tank when the engine is running
k. Do **not** operate a vehicle with a fuel leak

Vehicles

a. Be sure that a vehicle is out of gear before starting it
b. Be sure that an appropriate fire extinguisher is nearby when starting or running a vehicle in the shop
c. Use extreme caution when moving a vehicle in the shop; check around the vehicle and the planned path to make sure there are no obstacles in the way

d. Use a spotter to help you if trying to maneuver or park a vehicle in a close area
e. Do **not** leave a vehicle running in the shop without adequate exhaust-removal equipment in place
f. Be careful of moving parts on the vehicle, such as belts and fans
g. Be careful of parts that heat up during engine operation
h. Do **not** allow tools or other metal objects to contact both battery terminals at the same time
i. Wear gloves and protective clothing when handling batteries
j. Wear your safety belt whenever you ride in or drive a vehicle, including test drives—no matter how short
k. Avoid using remote starters; start the vehicle with the ignition switch to ensure proper control
l. Warn other workers in the area and clear workers from the engine area when starting a vehicle

OBJECTIVE 3

- Worker standing on creeper
- Worker wearing jewelry
- Worker not wearing eye protection
- Worker operating lift controls with other worker under vehicle
- Gasoline spilled on floor
- Gasoline improperly stored
- Tools lying on floor
- Rags improperly stored
- Troublelight cord strung through work area
- Troublelight cord running through spilled gasoline
- Troublelight not properly stored

OBJECTIVE 8

a. Federal safety red
b. Federal safety blue
c. Federal safety black and white
d. Federal safety green
e. Federal safety yellow

OBJECTIVE 10

a. 1
b. 2
c. 2
d. 2
e. 2
f. 2

OBJECTIVE SHEET

UNIT A-3 DEVELOP FIRST-AID SKILLS

INTRODUCTION

As an automobile service specialist, you will quite likely see or perhaps even be the victim of a serious injuring accident. The key to handling such an accident will be your ability to analyze the situation and then decide what needs to be done. You will be able to do that by learning ahead of time the first-aid actions the Red Cross and other experts say should be followed. The information and skills covered in this unit can help you stay calm and know what needs to be done when an injuring accident occurs.

UNIT OBJECTIVE

After completing this unit, the student should be able to perform basic first-aid treatment for accident victims. The student will demonstrate these competencies by completing the assignment sheet, job sheet, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit A-2, "Learn and Apply General Safety Practices."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with first aid by choosing the correct definition from a list of three choices.
2. Recall the sequence for giving first-aid actions in an emergency by numbering given steps in the correct order.
3. Determine pressure points to use to control bleeding by indicating on a drawing pressure points to be used in a given situation.
4. Recognize the symptoms of traumatic shock by selecting symptoms from a list.

5. Classify burns according to their symptoms by stating the degree of burn in a given situation.

6. Apply guidelines for administering first aid for an eye injury by selecting the guidelines to follow in a given situation.

7. Recall measures to take for the prevention of heat stroke, heat cramps, and heat exhaustion by stating the measure when given a key word or phrase for each measure.

8. Distinguish between heat stroke and heat exhaustion according to their symptoms by stating whether heat stroke or heat exhaustion is being described in a given situation.

9. Perform first-aid treatment for simulated accident victims. (Job Sheet 1)

10. Analyse case studies to determine correct first-aid treatments. (Assignment Sheet 1)

SUGGESTED ACTIVITIES	DEVELOP FIRST-AID SKILLS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  NOTE: Some of the skills in this unit need to be taught by a certified first-aid/CPR instructor. If you are not a certified instructor, we highly recommend that you become certified before teaching "Develop First-Aid Skills." Contact your local Red Cross office for a certification course or to arrange for one of their instructors to teach those skills for you if you cannot become certified in time to teach it yourself. The use of a certified professional not only ensures the quality of the instruction but also stresses the importance of these skills to the students.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Review unit and other first-aid regulations to make sure that your shop is in compliance. Develop first-aid skills yourself, and update yourself periodically. Put up posters, charts, and signs.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss introduction to the unit (see "Objective Sheet").
- Discuss the Good Samaritan Act. Is it active in your community? How active is it? What persons does it specifically cover?
- Use instances that you know of or have heard about, or use case studies, to point out the importance of knowing how to administer first aid.

Objective 1 Recognize definitions of terms associated with first aid

- Provide the students with examples to illustrate terms whenever possible. For example, show a *tourniquet* or pictures of *fractures*.
- Post signs, posters, and pamphlets that have illustrations of terms.
- Copy and hand out Supplement 1, "First-Aid Crossword Puzzle." Inform students of how the assignment should be completed and how it will be used in class. For example, you may let students work on it throughout the teaching of this unit or you may allow them to work on it in teams.

Objective 2 Recall the sequence for giving first-aid actions in an emergency

- Invite a nurse or Red Cross representative to discuss first aid.
- Provide students with copies of Supplement 2, "General Directions for Giving First Aid," and discuss ways they can make good use of it.
- Supplement your discussion with material from the American Red Cross books, *Standard First Aid* and *Personal Safety and Multimedia Standard First Aid Student Workbook*. Encourage students to obtain their own copies of these manuals for home and work-site reference.
- Discuss the logic behind the sequence of the emergency steps.
- Point out that Job Sheet 1, "Perform First-Aid Treatment for Simulated Accident Victims," is organized in the order of the emergency steps.
- Discuss the introduction to Job Sheet 1.

- Encourage students to learn CPR and other first-aid measures. Give extra credit or other rewards. When giving extra credit in this or other units, relate it to bonuses provided in the trade. For example, explain that an employer may pay for an automotive technician to attend a vehicle manufacturer's training program or may give a pay raise to a mechanic who obtains ASE certification.

- Have a certified CPR instructor come to class to demonstrate and teach cardiopulmonary resuscitation.

- Have students practice procedure for adult victim of suspected cardiopulmonary arrest in Job Sheet 1. Emphasize to students that they should never practice CPR on a breathing person—a resuscitation doll must always be used for practice. Also stress the importance of preventing the spread of disease by using a clean dressing saturated with bleach solution (1 tablespoon bleach in 1 gallon of water) to clean the doll after each use.

- Carefully explain your school's policy on student use of first aid, but continue to emphasize the use of common sense in any emergency.

Objective 3 Determine pressure points to use to control bleeding

- Discuss bleeding and how quickly death can occur because of it. Point out that the average adult will normally have about five quarts of blood. Show the students five quarts of liquid, emphasizing how little volume it is. Explain that a person's heart may stop beating with as little as two quarts of blood lost.

- Remind students that pressure points are used only when bleeding cannot be controlled by direct pressure to the wound.

- Remind students that bleeding victims should be observed for signs of shock and treated accordingly.

- Explain the difference between arterial and venous bleeding: *Arterial bleeding* is bright red and spurts or flows intermittently; *venous bleeding* is dark red and flows continuously. Immediate steps must be taken to stop arterial blood flow, as this is a life-threatening situation. Often even heavy pressure to a pressure point is ineffective in stopping arterial bleeding. In such cases, the severed artery must be found and pinched closed with the fingers. Direct pressure is usually effective in controlling venous bleeding.

- Demonstrate the steps to control bleeding by direct pressure outlined in Job Sheet 1. Have students practice applying pressure to simulated bleeding (both arterial and venous) on various parts of the body by following steps outlined in the appropriate section of Job Sheet 1.

- Caution students that tourniquets are used ONLY as a last resort. Explain that while a tourniquet may be necessary to save a person's life, it cuts off circulation and may cost the victim his or her limb. Stress that if a tourniquet must be used, the victim must be seen by a physician as soon as possible.

- Explain what to do if the victim has severed a finger, hand, or limb. Tell students that bleeding should be controlled by applying pressure to the correct pressure point, and that the severed appendage should be wrapped in a clean cloth or placed in a clean plastic bag and be transported to the hospital with the victim. If possible, the appendage should also be kept cool with ice; but the ice must not be allowed to directly touch the appendage.

Objective 4 Recognize the symptoms of traumatic shock

- Discuss traumatic shock, emphasizing that some degree of shock can occur with almost any injury.

- Have students check their own pulse in the wrist and neck, and have them pair off and check another person's. Point out how a pulse feels and its frequency.

- Discuss other types of shock, and be sure the students understand the differences.

- Demonstrate treatment for traumatic shock as outlined in Job Sheet 1.

- Allow students to practice treatment procedures.

Objective 5 Classify burns according to their symptoms

- Obtain posters showing the different types of burns.

- Invite a burn victim to talk to the class about his or her experiences.

- Emphasize burn sources in the shop, and discuss complications that are likely to occur, such as contamination by engine coolant or battery acid in burns from those sources.

- Demonstrate burn treatment procedures using Job Sheet 1 and emphasize using available first-aid supplies. Set up realistic shop situations.

- Allow students to practice burn-treatment procedures.

Objective 6 Apply guidelines for administering first aid for an eye injury

- Show films, *Eye Injuries*, *An Option to See*, *Don't Push Your Luck*, and *It's Up to You*.

- Invite a person blinded in an automotive shop accident to the class to discuss his or her experiences.

- Blindfold students and ask them to do certain tasks that rely on sight so that they can gain an appreciation of the problems experienced by the blind.

- Discuss the use of eye protection, relating it to the shop and to people such as Kareem Abdul-Jabbar. Read the box material with this objective and discuss with the class.

- Demonstrate eye-treatment procedures as outlined in Job Sheet 1.

- Allow students to practice eye-treatment procedures.

Objective 7 Recall measures to take for the prevention of heat stroke, heat cramps, and heat exhaustion

- Provide students with Supplement 3, "How to Beat the Heat," and discuss heat-related problems.

- Have students read the box material with this objective; discuss in class.

- Use thermometers to demonstrate high temperatures around the shop and in typical service areas.

- Discuss the need to drink plenty of water to prevent dehydration and possible heat stroke or heat exhaustion. Water is better than sweet or electrolyte drinks because water leaves the stomach faster and is more quickly available for the tissues. Discuss also the need for increasing one's salt intake and eating a balanced diet. Using a little extra table salt can help replace sodium and chlorine lost through heavy perspiration. Salt tablets are not recommended. A balanced diet of whole-grain cereals, fruits, vegetables, milk, meat, poultry, and fish will supply potassium and other mineral elements lost through heavy perspiration.

Objective 8 Distinguish between heat stroke and heat exhaustion

- Use Transparency 1, "Face and Skin Conditions in Heat Stroke and Heat Exhaustion," to discuss symptoms of heat stroke and heat exhaustion. You may want to color the red skin color on the heat-stroke victim.

- Discuss other symptoms that may occur, pointing out that many are similar and that is why the primary different symptoms are important.

- Give students examples of possible shop situations that could lead to heat distress, and demonstrate treatment procedures as outlined in Job Sheet 1.

- Allow students to practice procedure for victim of heat distress in Job Sheet 1.

Objective 10 Analyze case studies to determine correct first-aid treatments

- After students have practiced the first-aid procedures in Job Sheet 1, have them complete the assignment sheet, and discuss in class. Stress to students that the first step they should take in an emergency is to evaluate the situation and determine the nature and the extent of the injuries so that proper treatment can be given. This assignment gives practice in using the evaluation skills that can save the lives of their co-workers.

EVALUATION

- Give written test.

- Give practical test, and evaluate test on forms provided.

  NOTE: Copy the practical-test evaluation form as many times as necessary to have students demonstrate the various first-aid procedures discussed in Job Sheet 1. Simulate the situations as accurately as possible, giving the students enough details and variables to test their cognitive as well as their psychomotor skills.

- Reteach and retest as required.

- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- American Red Cross. *Standard First Aid and Personal Safety*, 2nd ed. Garden City, New York: Doubleday and Company, Inc., 1979.

- *First Aid.* Washington, D.C.: United States Department of Labor, Bureau of Mines, 1978.

Media

NOTE: The following films are available to Oklahoma teachers on a free-loan basis. Oklahoma teachers may order these films from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074. Out-of-state teachers must order from the addresses listed with the films.

- *An Option to See.* Color, 18 minutes, Oklahoma Society to Prevent Blindness, 1977. Available from Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074. This safety film stresses the importance of wearing safety glasses while working around machinery.

- *Don't Push Your Luck.* Color, 12 minutes, Harvest Films, Inc., 1978. Available from Harvest Films, Inc., 309 Fifth Avenue, New York, New York 10016. In this film Bill Frank, an actual victim, re-creates his real-life blinding accident. He delivers powerful safety messages to industrial employees and shows proper eye and face protection.

- *It's Up to You.* Color, 11 minutes, Harvest Films, Inc., 1960. Available from Harvest Films, Inc., 309 Fifth Avenue, New York, New York 10016. This is an award-winning break-through film on eye safety.

- *Eye Injuries.* Color, 6 minutes, International Film Bureau, 1981. Available from International Film Bureau, Inc., 332 South Michigan Avenue, Chicago, Illinois 60604. This film demonstrates the procedure for removing particles from under the eyelids.

- *On Every Hand.* Color, 10 minutes, Journal Films, Inc., 1970. Available from Journal Films, Inc., 930 Pitner Avenue, Evanston, Illinois 60202. This film demonstrates how to avoid serious hand injuries that could be caused by commonly used and dangerous equipment.

Print media

- Books

  NOTE: The following books are available from the American Red Cross, 17th and D Streets, Washington, D.C. 20006.

  — *Standard First Aid*

  — *Personal Safety and Multimedia Standard First Aid Student Workbook*

- Competency profiles and transparencies

  NOTE: Competency profiles and transparencies for this book are available from the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- First-aid posters and pamphlets

  NOTE: First-aid posters and pamphlets, as well as other resources, are available from local hospitals, doctors, and Red Cross offices.

DEVELOP FIRST-AID SKILLS

SUPPLEMENT 1

First-Aid Crossword Puzzle

Test yourself on first-aid terminology by using the clues below to complete the following crossword puzzle.

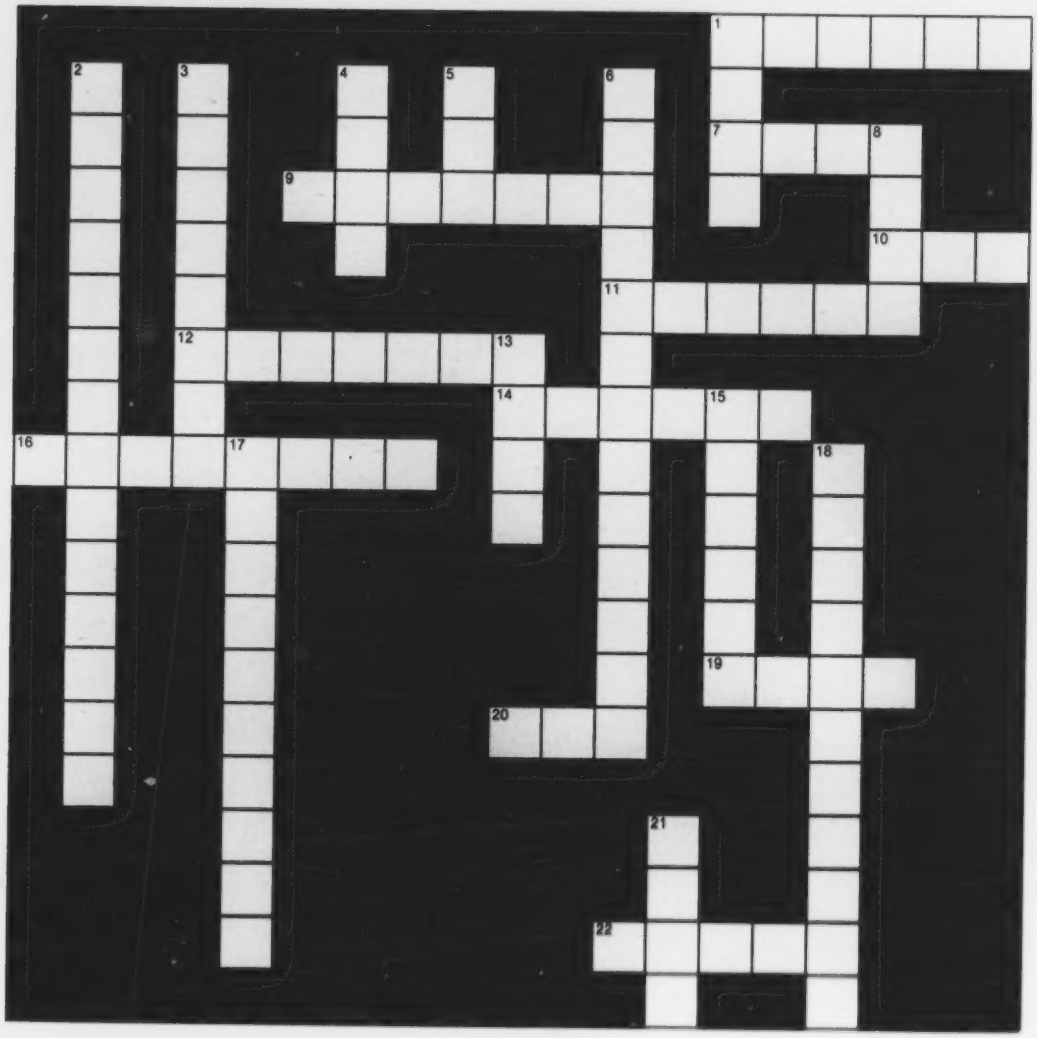
ACROSS

1. Fracture with broken bone beneath the skin with no open wound
7. Shock can be caused by _____ of blood
9. Intensity indicators for first-, second-, and third-
10. Action that eases heat cramps
11. Life-threatening disorder caused by prolonged exposure to intense heat
12. Bodily injuries, wounds, or shock
14. Complaint of victim in early stages of traumatic shock
16. Immediate temporary care given to the victim of an accident or sudden illness until the services of a physician can be obtained (two words)
19. To become in need of rest; to become weary
20. Cause of heat stress
22. What one should never do to an open fracture

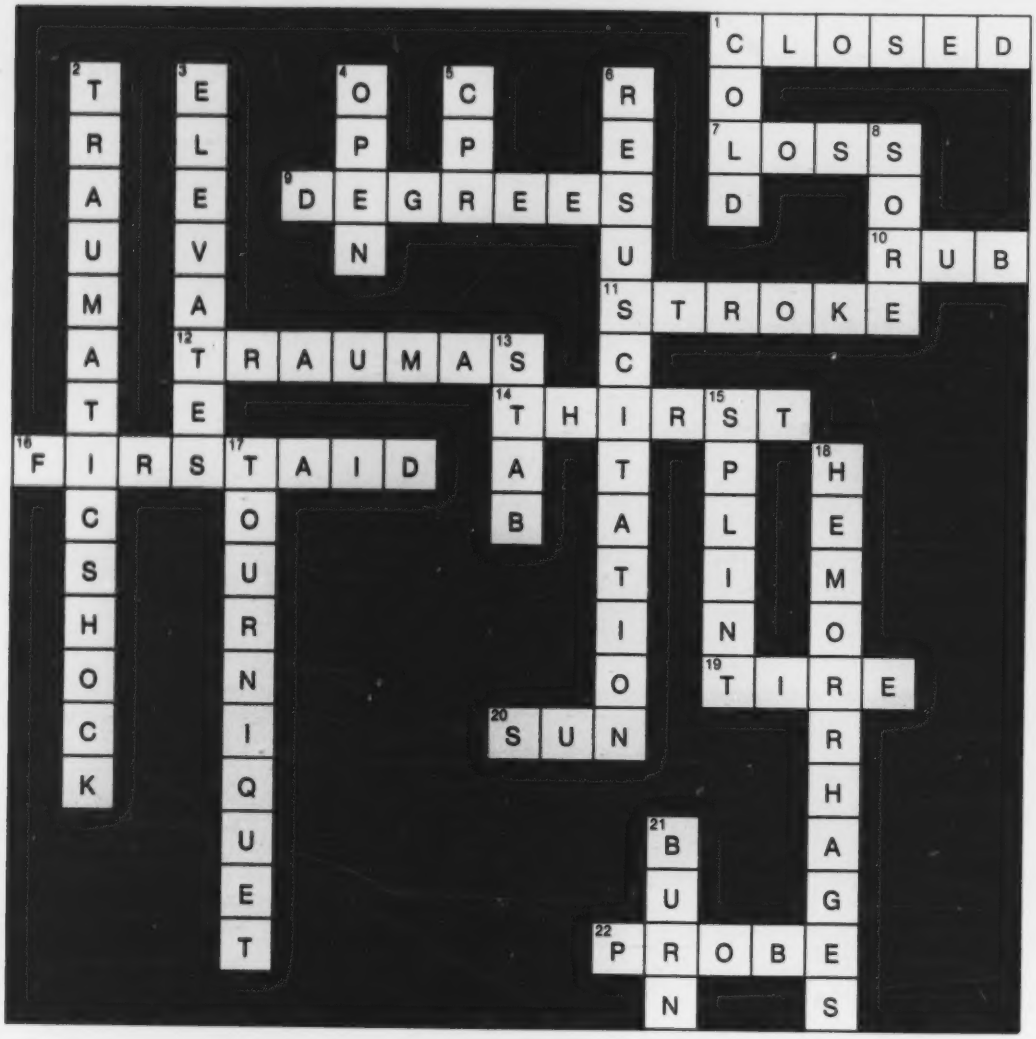
DOWN

1. Water temperature for treatment of second-degree burn
2. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body (two words)
3. Raises, as for an injured or bleeding limb
4. Fracture associated with open wound
5. Cardiopulmonary resuscitation (abbreviation)
6. Act of reviving a person by bringing person back to full consciousness
8. Tender; painful
13. Wound made by piercing with a sharp instrument
15. Device used to prevent fractured bones and adjacent joints from moving
17. Any device, such as a bandage and stick, used to compress a blood vessel to stop bleeding
18. Heavy loss of blood
21. Injury caused by contact with heat, steam, electricity, or flame

First-Aid Crossword Puzzle



Answers to First-Aid Crossword Puzzle



SUPPLEMENT 2 — General Directions for Giving First Aid

American Red Cross

Keep the injured person lying down. **Do not give liquids**

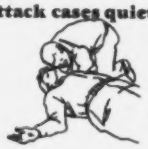
to an unconscious person. **Restart breathing with mouth-to-mouth**

artificial respiration. **Control bleeding by pressing on the wound.**

Dilute swallowed poisons **and call the Poison**

Control Center. Keep broken bones from moving. **Cover burns**

with thick layers of cloth. **Keep heart-attack cases quiet and give**

cardiopulmonary resuscitation (CPR) if it is necessary  **and if you**

have been trained. Keep a fainting victim lying flat.

For eye injuries, pad and bandage both eyes. **Always call a doctor.**

For more information about these and other lifesaving techniques, contact your Red Cross chapter.

American Red Cross Poster

Emergency Telephone Numbers

Rescue Squad _____

Fire Department _____

Police _____

Physician _____

Hospital Emergency Room _____

Poison Control Center _____

Additional Numbers _____

When you call for emergency help, tell:

1. WHERE the emergency situation is, with cross streets if possible.
2. TELEPHONE NUMBER you are calling from.
3. WHAT HAPPENED—heart attack, auto accident, fall, etc.
4. HOW MANY persons need help.
5. WHAT is being done for the victims.

NOTE: YOU HANG UP LAST. Let the person you called hang up first.

Record and post emergency telephone numbers in advance so that they will be readily available when you need them.

The programs of the American Red Cross are made possible by the voluntary services and financial support of the American people.

Poster 1023-A
Rev. Mar. 1983

American Red Cross poster

SUPPLEMENT 3 | How to Beat the Heat

HOW TO BEAT THE HEAT

Reactions to hot weather vary with a person's age, general physical condition, and activity level. Older people, small children and very active young people are the most likely to suffer from heat illness.

The human body is capable of adapting itself to varying temperature conditions, but the combined effect of heat and heavy physical exertion may be too much for the body's natural temperature regulator. Heat can make some people sick, and in some cases, it can kill.

Here's what happens. The body itself produces metabolic heat — more heat when you're working or playing than when resting. Outdoors on a sunny day, radiant energy adds heat to the body. If the air is warmer than the body temperature, more heat may be added.

The body's heat regulation system tries to maintain a fairly constant temperature of about 98°F. To cool the body, the heart pumps blood out to the extremities—arms and legs—where the heat is dispersed. Another way the body eliminates heat is through the cooling evaporation of sweat. A cool breeze and low humidity help body cooling. High humidity interferes with sweating and adds to discomfort.

Some of the more common forms of heat illness are as follows:

HEAT SYNCOPY OR HEAT FAINTING

This is common among people who are not acclimated to hot weather. It normally occurs soon after someone goes out into the heat to work or exercise. The blood pressure falls suddenly as blood flows to the extremities to cool the body and not enough goes to the head. The person feels giddy, light headed and then passes out. The best first aid is to have the person lie down to rest and elevate the feet.

HEAT CRAMPS

These muscular cramps result from exposure to high temperatures for a relatively long period of time, coupled with physical exertion. Heavy sweating and dehydration usually precede the cramps.

HEAT EXHAUSTION

This occurs after some hours in the sun and is related to loss of water and salt through sweating without sufficient fluid replacement. Common symptoms include a subnormal body temperature; pallor; dizziness; profuse sweating; cool, moist skin; nausea and headaches. The best first aid is to have the person rest in a cool place and drink water or fruit juice. If the person doesn't feel better in an hour or two or can't hold liquids, take him/her to a hospital emergency room.

HEAT STROKE

This condition can prove to be fatal, so immediate medical attention is necessary. It is caused by a complete breakdown of the body's heat regulating system, with heat production exceeding heat loss. Common symptoms include hot, dry skin, little or no sweating, severe headache, visual disturbance, rapid temperature rise, loss of consciousness, flushed face, weakness and confusion.

First aid treatment should be aimed at cooling the body quickly and getting the victim to the hospital. Remove the person from the source of heat, loosen the clothing, and try to cool the body as rapidly as possible, using a cool bath or cold compresses. Don't give water to a heat stroke victim.

So when the temperatures begin to soar upward, take a few precautions to minimize your body's level of heat stress:

- Try to take frequent rest periods.
- Space heavier workloads or workouts throughout the day, rather than concentrating them in a few consecutive hours.
- Avoid heavy activity during the hottest part of the day.
- Drink plenty of water or other fluids.
- Wear loose, light clothing that reflects the sun's rays and allows sweat to evaporate. A hat will add further protection.

Coping with summer heat is just a matter of using common sense.

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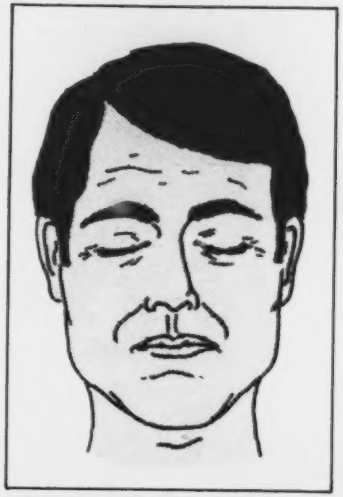
Face and Skin Conditions in Heat Stroke and Heat Exhaustion

Heat Stroke

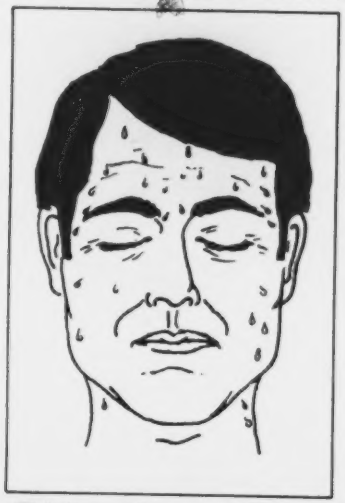


Skin Condition

Hot Red Dry

Cool body quickly.
Get immediate medical help.

Heat Exhaustion



Skin Condition

Clammy Pale Heavy Sweating

Get victim out of sun and heat, elevate feet, cool body, give sips of salt water.

PRETEST ANSWERS

DEVELOP FIRST-AID SKILLS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 23, 24, 25
2	2
3	8, 17
4	3, 18
5	4, 19
6	5, 20
7	6
8	7, 21
9	9, 10, 11, 12, 13, 14, 15, 16, 22
10	9, 10, 11, 12, 13, 14, 15, 16, 22

ANSWER KEY

1. c
2. b
3. c
4. d
5. b
6. b
7. a
8. c
9. a
10. b
11. a
12. b
13. d
14. a
15. d
16. d
17. b
18. a
19. d
20. d
21. c
22. c
23. c
24. b
25. a

PRETEST

DEVELOP FIRST-AID SKILLS

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which of the following is the best definition of *resuscitation*?

   a. Motion of pistons in a cylinder
   b. Act of extinguishing a fire
   c. Act of reviving a person by bringing the person back to full consciousness
   d. Any suddenly occurring, unintentional event that causes injury or property damage

2. When giving first aid to a person who has fallen against a radiator fan and is badly cut, what are the first three things you should do?

   a. Rescue the victim and yourself, restore or maintain breathing and heartbeat, and seek medical help
   b. Rescue the victim and yourself, restore or maintain breathing and heartbeat, control heavy bleeding
   c. Rescue the victim and yourself, examine the victim carefully, and seek medical help
   d. Rescue the victim and yourself, prevent shock, and control heavy bleeding

3. Which of the following symptoms might indicate that an accident victim was experiencing traumatic shock?

   a. Moist, clammy skin; high fever; and babbling
   b. Moist, clammy skin, low body temperature, and constricted pupils
   c. Moist skin with spotty appearance, rapid pulse, and dilated pupils
   d. None of the above

4. A third-degree burn may produce

   a. Redness, mild swelling, and mild pain
   b. Blistering, considerable swelling, and great pain
   c. Redness, considerable swelling, and deep tissue destruction
   d. Charred or white appearance, little or no pain, and deep tissue destruction

5. Technicians A and B are trying to help one of their co-workers with a metal chip that has penetrated his eye. Technician A says that they should wash the eye or try to remove the chip. Technician B says that they should get medical help immediately and cover both eyes lightly with a clean dressing.

   Who is right?

   a. Technician A
   b. Technician B
   c. Both A and B
   d. Neither A nor B

6. To help prevent heat cramps and heat exhaustion, you should

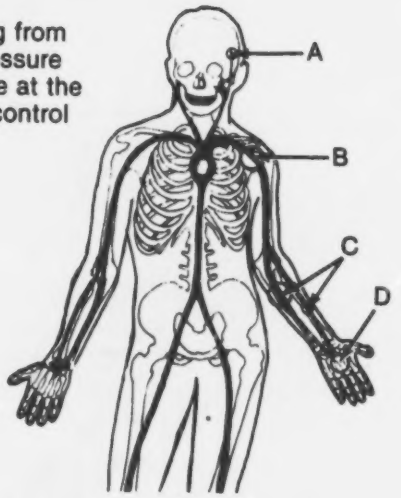
   a. Decrease fluid intake so that body salts will build up
   b. Drink plenty of fluids
   c. Wear heavy clothing to absorb sweat
   d. Both a and c

7. One hot day while working in a tightly closed shop, another technician tells you that she feels dizzy and has a headache. She suddenly faints. Her skin is red, hot, and dry. She could be suffering from

   a. Heat stroke
   b. Carbon monoxide poisoning
   c. Heat cramps
   d. Heat exhaustion

8. If a person were bleeding from the lower arm, which pressure control point in the figure at the right should be used to control bleeding?

   a. A
   b. B
   c. C
   d. D



9. When giving CPR to an adult, as you breathe into the victim, you should

   a. Keep the victim's head tilted back slightly, lifting the victim's chin to maintain an open airway, and pinch the victim's nostrils shut
   b. Continue to breathe in until the victim's chest rises and falls
   c. Leave the victim's nostrils open or leave a slight opening around the mouth to allow air to escape
   d. Breathe in approximately twenty times

10. While working on a car, Technician C jabs a screwdriver deep into his leg and begins bleeding heavily. Technician A and B are trying to give first aid. Technician A says that they should first remove the screwdriver, and Technician B says that it should be left in.

    Who is right?

    a. Technician A
    b. Technician B
    c. Neither. The screwdriver should be removed and then reinserted if the bleeding increases
    d. Neither. The screwdriver should be left in until a tourniquet has been applied and then it should be removed

11. For a victim of swallowed noncorrosive poisoning, the safest action to follow if treatment requirements are not known is to

    a. Have the victim drink water or milk
    b. Try to get the victim to vomit
    c. Have victim recline with the head lower than the stomach
    d. All of the above, until medical help arrives

12. If someone shows signs of traumatic shock, you should

    a. Have the person walk around and make sure that he or she does not go to sleep
    b. Have the person lie down and cover him or her with a blanket
    c. Loosen person's clothing and give him or her cool water to drink
    d. Give mouth-to-mouth resuscitation immediately

13. To treat a person with heat stroke, you should

    a. Move victim out of sun, preferably to an air-conditioned room
    b. Soak victim in cool but not cold water
    c. Transport victim to hospital immediately
    d. All of the above

14. Technician H has been splattered with gasoline and burned when the gasoline caught fire. The resulting wound is deep with a lot of tissue damage. Technician H does not feel much pain but his clothing is still smoldering. Technician A says that the smoldering clothing should be removed and the burned area immersed in clean, cold water. Technician B says that a burn ointment should be applied and Technician H should be rushed to the hospital.

    Who is right?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

15. An eye that has been splattered with battery acid should be flushed gently with room-temperature water for at least how many minutes?

    a. 2
    b. 5
    c. 10
    d. 15

16. If giving first aid to someone with a broken bone sticking through a wound in the person's leg, you should

    a. Push the bone in before treating the wound so that bleeding will not increase
    b. Allow the bone to protrude until you wrap the wound and then use the bandage to pull the bone back into place
    c. Allow the bone to protrude until you apply the splint and then move the bone gently back into its approximate position before tightening the splint wraps
    d. Not push the bone back into the leg

17. In trying to control bleeding, three techniques may be used. The techniques should be followed in order, with the first-aid giver stopping with the technique that works. The correct order, beginning with the first technique to be tried, is

    a. Direct pressure on the wound, a tourniquet, and as a last resort pressure at a pressure point
    b. Direct pressure on the wound, pressure at a pressure point, and as a last resort a tourniquet
    c. Pressure at a pressure point, a tourniquet, and as a last resort packing the wound with ice
    d. Pressure at a pressure point, packing the wound with ice, and as a last resort a tourniquet

18. Which of the following is **not** likely to be a symptom of traumatic shock?

    a. High body temperature
    b. Weakness
    c. Rapid breathing
    d. Excessive thirst

19. Symptoms of a second-degree burn include

    a. Red, spotty appearance
    b. Blistering
    c. Great pain
    d. All of the above

20. When giving first aid for an object stuck in the eye, the best way to remove an object that penetrates the eye is with

    a. Gently flowing water
    b. A clean, soft cloth
    c. Tweezers
    d. None of the above

21. Technicians A and B are discussing the symptoms of heat exhaustion. Technician A says that with heat exhaustion the victim's body temperature is high but the skin may look pale and feel cool and clammy. Technician B says that the victim's body temperature is normal but the skin may look red and feel hot and dry.

Who is right?

a. Technician A
b. Technician B
c. Neither A nor B
d. Both A and B

22. Technicians A and B are discussing CPR. Technician A says that the first-aid giver should continue CPR until pulse is present and victim is breathing on his or her own or until medical help arrives. Technician B says that there is no need to give CPR for more than five minutes because a person will be dead if he or she has no pulse and has not breathed for five minutes.

Who is right?

a. Neither A nor B; the correct time is ten minutes
b. Neither A nor B; the correct time is fifteen minutes
c. Technician A
d. Technician B

23. *Traumatic shock* is a

a. State of unconsciousness caused by the inhalation of toxic gases
b. State of unconsciousness caused by large amounts of electricity flowing through the body
c. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body
d. Depressed condition of many of the body functions due to overexposure to high temperatures or insufficient intake of liquids

24. Which of the following best defines a *tourniquet*?

a. Device used to pack a wound in ice and apply direct pressure to a pressure point
b. Device, such as a bandage and stick, used to compress a blood vessel to stop bleeding or to control blood flow
c. Device used to pry open the mouth of a choking victim
d. Device used to stop bleeding from a minor neck wound

25. Which of the following best defines a *hemorrhage*?

a. Heavy loss of blood
b. Broken bone associated with an open wound
c. Broken bone beneath the skin with no open wound
d. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body

INFORMATION SHEET	DEVELOP FIRST-AID SKILLS

OBJECTIVE 1

Recognize definitions of terms associated with first aid

First aid — Immediate, temporary care given to the victim of an accident or sudden illness until the services of a physician can be obtained

Resuscitation — Act of reviving a person by bringing the person back to full consciousness

EXAMPLES: Mouth-to-mouth resuscitation, cardiopulmonary resuscitation (CPR)

Traumatic shock — Depressed condition of many of the body functions due to failure of enough blood to circulate through the body

Tourniquet — Any device, such as a bandage and stick, used to compress a blood vessel to stop bleeding or to control blood flow

NOTE: Tourniquets are used only for severe, life-threatening hemorrhage that cannot be controlled by any other means.

Hemorrhage — Heavy loss of blood

Closed fracture — Broken bone beneath the skin with no open wound

Open fracture — Broken bone associated with an open wound

EXAMPLES: Broken bone end tears through skin, machinery penetrates skin and breaks one or more bones

OBJECTIVE 2

Recall the sequence for giving first-aid actions in an emergency

1. Rescue victim and yourself
2. Restore or maintain breathing and heartbeat
3. Control heavy bleeding
4. Treat for poisoning
5. Prevent traumatic shock
6. Examine victim carefully to evaluate injury
7. Seek medical help
8. Keep checking and assisting victim until medical help is obtained

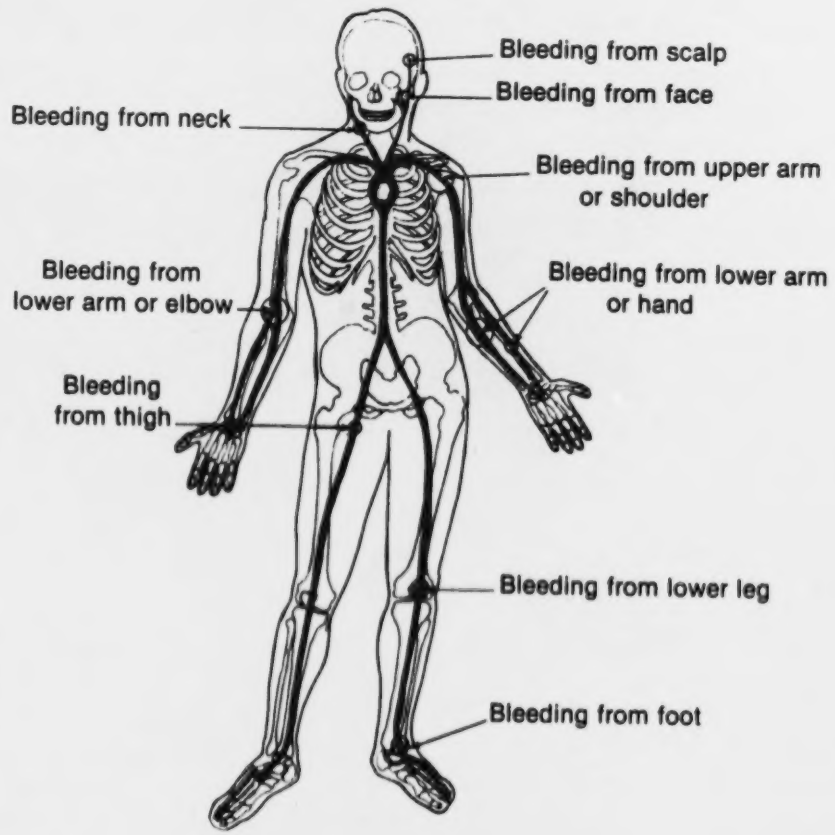
One step more . . .

The actions listed above are taken from a book called *Standard First Aid and Personal Safety*, which is published by the American Red Cross. The steps are designed to help you handle an emergency by considering the entire situation. An accident affects not only a person's physical condition, but also his or her emotional and mental conditions. *First aid* is intended to prevent such situations from becoming more serious—for example, by helping the victim to live instead of die, by keeping a disability temporary instead of permanent, by promoting rapid recovery instead of long-term healing. Everyone should know some basic first aid, but you may wish to learn more. The Red Cross and other organizations in your community probably offer such courses. This training may even be available in your school. Check into available sources of first-aid training if you are interested, and then talk to your instructor about possible extra credit for such training.

OBJECTIVE 3 | **Determine pressure points to use to control bleeding**

NOTE: Pressure points are used to control bleeding from severe wounds if direct pressure on the wound is not enough to slow bleeding.

FIGURE 1


Bleeding from scalp
Bleeding from face
Bleeding from neck
Bleeding from upper arm or shoulder
Bleeding from lower arm or elbow
Bleeding from lower arm or hand
Bleeding from thigh
Bleeding from lower leg
Bleeding from foot

Pressure points

Steps in Controlling Bleeding

If someone is bleeding badly, first apply pressure directly to the wound and elevate the area that is bleeding (position wounded area so that it is higher than the heart). Apply pressure with a cloth or bandage if available. If the bleeding continues or if the wound is too large, apply pressure at one of the control points shown above, using these guidelines:

(1) Use the control point between the heart and the wound that is closest to the wound.
(2) Apply only enough pressure to slow the bleeding.
(3) Release pressure when the bleeding has slowed.

Use a tourniquet only if the bleeding is likely to result in death, as in the loss of a limb.

OBJECTIVE 4

Recognize the symptoms of traumatic shock

Early stages

- Pale or bluish skin that is cool to the touch
- Moist, clammy skin if perspiration has occurred
- General weakness
- Rapid, weak pulse
- Rapid, shallow, possibly irregular breathing
- Restlessness or anxiety
- Vomiting or nausea
- Excessive thirst

Late stages

- An attitude of not caring
- Unresponsiveness
- Sunken eyes with dilated pupils
- Spotty or mottled appearance of skin
- Low body temperature
- Loss of consciousness, leading to death if untreated

Traumatic Shock

A trauma is anything that physically injures or emotionally upsets a person. Traumatic shock is the body's reaction to a trauma. Traumatic shock is often referred to simply as *shock*, but do not confuse traumatic shock with electrical shock. Electrical shock is what happens when electricity flows through the body and can lead to traumatic shock. In fact, traumatic shock is likely to occur with any type of injury, even something as minor as banging your thumb with a hammer. However, in more serious injuries, traumatic shock can become more severe, and it can even lead to death although the injury itself was not serious enough to be fatal. That is why it is important to recognize and treat shock. To help you in this, check your pulse while you are resting. It should be about 70 to 80 beats per minute. Sometimes a person with traumatic shock will have a weak pulse, and you will have to check the pulse in the victim's neck.

OBJECTIVE 5

Classify burns according to their symptoms

First-degree burns

- Redness and discoloration
- Mild swelling
- Mild pain

Second-degree burns

- Red, spotty appearance
- Damage below the skin
- Blistering
- Wet appearance of the burned area
- Considerable swelling
- Great pain

Third-degree burns

- Charred or white appearance
- Deep tissue destruction
- Less pain

NOTE: There is little or no pain in the burned area because the nerves have been destroyed.

DANGER:
Sources of Burns in the Automotive Repair Shop

- Hot exhaust systems
- Hot coolant hoses and radiators
- Steam or coolant from radiators
- Power tools
- Catalytic converters
- Batteries and electrical components
- Hot oils and fluids
- Welding equipment
- Fires from flammable liquids
- Drop lights

Can you think of others?

OBJECTIVE 6

Apply guidelines for administering first aid for an eye injury

NOTE: Keep eye-injury victim flat on back if injury is caused by a penetrating object or severe blow; do **not** wash out eye with water; do **not** try to remove object penetrating the eye.

For objects or chemicals in the eye that do not cut or penetrate the eye

- Flush eye with room-temperature water or solution designed for flushing eyes
- Use clean, soft cloth to gently try to remove object
- Do not use hard or sharp objects to try to clean eye

  EXAMPLES: Tweezers, brushes, toothpicks
- Do not allow victim to rub eyes

For cuts of the eye or eyelid or objects that penetrate eye or that cannot be removed using above procedure

- Get medical help immediately
- Do not wash eye
- Do not try to remove object
- Cover eyes lightly with clean dressing

  NOTE: The purpose in covering the eyes is to keep the person from blinking. For this reason both eyes must be covered, not just the injured eye.

Kareem Abdul-Jabbar

A lot of people avoid using protective devices of any kind. Some refuse because they're trying to show how tough they are, while others are concerned about how the protective devices make them look. But failing to protect yourself isn't tough, and the scars or damage from an injury won't help your appearance. Kareem Abdul-Jabbar, the great basketball player, has done a lot to change some people's thinking about protective devices, especially eye protection. Kareem wears goggles when he plays basketball, and he is convinced that they have saved him from getting fingers and elbows in his eyes many, many times. A lot of people laughed when they first saw the goggles but now many players wear them. Eye protection isn't any different than wearing football pads or a batting helmet. Getting an eye gouged is painful and it can blind you. Kareem's job depends on being able to see well. Does yours? Protect your eyes.

OBJECTIVE 7

Recall measures to take for the prevention of heat stroke, heat cramps, and heat exhaustion

- Drink plenty of fluids
- Increase salt intake
- Wear lightweight clothing that allows sweat to evaporate
- If outdoors, keep head and face shaded
- Take frequent, short work breaks
- Rest in shade or air-conditioned room whenever possible

HEAT

High temperatures can be harmful to the body. Your body is mostly water, and heat takes water away from your body. This can lead to cramps, the painful tensing of muscles. With extreme water loss, heat exhaustion can occur. Heat exhaustion can lead to your feeling very tired and faint. If the body becomes even more heat-stressed, a stroke can result, leading to possible paralysis, brain damage, and even death.

OBJECTIVE 8

Distinguish between heat stroke and heat exhaustion

Heat stroke

- Skin is flushed (red), hot, and dry
- Body temperature is high

Heat exhaustion

- Skin is pale, cool, and clammy
- Body temperature is normal

More Symptoms of Heat Stroke and Heat Exhaustion

The symptoms of heat stroke and heat exhaustion given above are the ones most obvious to someone seeing a person with such a problem. But other symptoms may also occur.

Heat stroke

- Dizziness
- Nausea
- Headache
- Rapid pulse
- Offensive body odor
- Unconsciousness

Heat exhaustion

- Heavy sweating
- Vomiting
- Headache
- Tiredness
- Weakness
- Fainting
- Cramps

One step more . . .

Some people do not realize that heat problems can occur even inside the shop. Try this experiment. Place a thermometer in an open area of the shop and another on the floor of a car in the shop. If it is a hot, sunny day, place a third thermometer where the sun is shining inside a car. Check the thermometers after ten minutes, and compare the temperatures. How much hotter is it in the cars than in the shop? How hot would it be in the cars if it were 95° F in the shop?

ASSIGNMENT SHEET 1

DEVELOP FIRST-AID SKILLS

OBJECTIVE 10

Analyze case studies to determine correct first-aid treatments

Name _____ Score _____

INTRODUCTION

Quick and effective use of first-aid procedures can save your life or the lives of your co-workers. Even in situations that are not life-threatening, first aid can reduce the seriousness of an injury or keep it from becoming life-threatening. The first step in any emergency situation is to determine the nature and the extent of the injuries so that you can determine the proper treatment.

DIRECTIONS

Read the following situations, and decide what kinds of first-aid treatment are required. State the problem you think is described in each situation, and then explain what you would do. Be specific enough to show that you understand the problem and the required treatment.

1. A co-worker was uncrating some parts and stepped on a nail. The nail penetrated his shoe and entered his foot. The nail comes out easily, and there is minimal bleeding. However, a few minutes later, he complains of feeling queasy. You notice that his face is pale and that his skin feels cool and clammy. After a moment, he says that he feels weak and wants to rest. What is the problem and how should it be treated?

   Problem: _____

   Treatment: _____

   _____

   _____

   _____

   _____

   _____

   _____

2. A worker was spraying penetrant near an open flame of a gas water heater. The spray ignited in a flash fire. The worker has burns over his face, hands, and forearms. He is experiencing intense pain when you arrive. His hands are swollen and covered with blisters. They appear to be wet, almost waxy. His eyebrows are burned away, and his face looks puffy. His face is covered with scattered blisters and dark red patches. What kind of burn does he have, and how do you treat it?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

3. A service specialist working near you has struck her hand in a cooling fan. Blood is gushing from the wound where the little finger has been severed and from a gash across her palm. When you wipe away the blood, streaks of white from tendons or bones show for a moment and then immediately disappear in the flow of blood. What actions should you take?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

4. One of your co-workers was plugging a battery charger into an extension cord in the wash bay when he screamed. There was a popping sound and a puff of smoke. The co-worker fell over and lay motionless on the floor. You turn off the electricity at the fuse box, and rush to the victim. When checking him, you find that his hand is swollen and blistered, mottled red, and smoke-scorched. Additionally, you notice that his lips and fingers are a bluish color. You check to see if he is breathing and find no sign of breath, though there is a weak pulse. What is the problem? What treatment is required?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

5. While opening a can of adhesive, a worker splatters the material into her eyes when the lid flies off suddenly. She grabs her eyes and begins screaming, "It burns! It burns!" What should you do?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

6. While working in the un-air-conditioned shop on a hot August day, one of your co-workers begins to complain of being dizzy. You notice that he is sweating heavily and looks pale. Suddenly, he straightens out his left leg and begins rubbing the calf and thigh. He pulls up his pants leg, and you see the muscles in his leg jerking spasmodically. What is the problem? What treatment should you provide?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

7. One of the workers on your job was pumping gasoline from a tank to a smaller can when there was a loud explosion. You look up to see her covered in flames. She begins running toward you, screaming. You knock her down and roll her on the ground to smother the flames. The gasoline continues to burn, but you have extinguished the flames on the victim's clothing. She is unconscious but breathing. Her pulse is rapid but weak. Her clothing is burned badly. Her legs are covered with ashy white burns surrounded by dark brown and black areas. Charred cloth from her pants is embedded in the burns. There is considerable blistering on her stomach, face, and hands. What is the problem? How should you care for the accident victim?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

8. You and a friend are working on the friend's truck at his home, which is 30 miles from the nearest medical help. Your friend, who is carrying a battery, slips and falls. The battery flies out of his hands and lands on his lower leg. Upon questioning him and examining his leg, you discover that his lower leg is bent at an odd angle and that there is discoloration, swelling, and considerable pain and tenderness at the injury site. What is the problem, and how would you treat it?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

ASSIGNMENT ANSWERS	DEVELOP FIRST-AID SKILLS

ASSIGNMENT SHEET 1

1. Traumatic shock
   - Have victim lie down, and raise his/her feet and legs if moving them does not cause pain
   - Cover victim
   - Get medical help as soon as possible

2. Second-degree burns
   - Submerge victim's hands in cold water and apply cold, wet cloths to other burned areas until pain eases
   - Blot dry gently with sterile dressing or clean, lint-free cloths
   - Apply sterile dressing, using care not to break blisters
   - Get medical help as soon as possible

3. Heavy bleeding
   - Apply a thick dressing (prepared gauze or clean cloth) directly over wounds and press with hands
   - Elevate wound if it does not cause victim pain
   - If bleeding is still active, apply pressure bandage—if bleeding continues, keep using direct pressure and use a pressure point until bleeding is under control
   - Treat victim for shock
   - Get medical help as soon as possible

4. Victim not breathing and has second-degree burns
   - Call for help
   - Position victim on back, open victim's airway, and ventilate victim until victim begins breathing
   - Treat for shock
   - Apply cold, wet cloths to burned area
   - Blot dry with sterile dressing or lint-free cloths
   - Apply sterile dressing
   - Get medical help as soon as possible

5. Foreign substance in eyes
   - Flush eyes with gentle stream of room-temperature water for at least 15 minutes
   - Gently place sterile gauze pad over both eyes
   - Transport victim to hospital immediately

6. Heat exhaustion and heat cramps
   - Move victim to air-conditioned room, and have victim lie down
   - Loosen victim's clothing, apply cool, wet cloths, and fan to promote cooling
   - Apply firm pressure and warm, wet towels to cramped area
   - Give sips of salt water
   - Transport victim to hospital

7. Second- and third-degree burns, shock
   - Treat for shock
   - Apply cold, wet cloths to stomach, face, and hands
   - Blot dry and apply sterile dressing, using care to not break blisters
   - Cover leg burns with dry, thick sterile dressing and immobilize burned area as much as possible
   - Transport victim to hospital as quickly as possible

8. Closed fracture
   - Immobilize the joints above and below suspected fracture with splints, taking care to move the bones as little as possible
   - Elevate limb slightly to reduce hemorrhage and swelling
   - Treat to prevent shock
   - Transport victim to hospital

JOB SHEET 1	DEVELOP FIRST-AID SKILLS

OBJECTIVE 9

Perform first-aid treatment for simulated accident victims

INTRODUCTION

Accidents are terrible enough in themselves, especially if someone is hurt. But all too often accidents are made worse because the people involved become excited and confused or just don't know what to do. In your career in automotive service it is quite likely that you will see or perhaps even be the victim of a serious injuring accident. Your best insurance for such an event is to prepare yourself ahead of time by taking three simple steps.

1. Learn and obey safety rules.
2. Examine the workplace and the jobs done so that you will be aware of the kinds of accidents that might happen.
3. Know how to give first aid.

Following these simple steps will increase your chances of avoiding an accident and of remaining calm and sensible should one occur.

The key to handling an accident once it happens is to analyze the situation and then decide what needs to be done. You have already learned the eight major actions that experts on emergencies say should be followed in the event of an injuring accident. Those steps are set up in order so that the most dangerous situations are handled first. For example, the first step is to rescue yourself and the victim. This may mean that you pull the victim away from a fire or out of a building filled with carbon monoxide or that you turn off power before touching an electrical shock victim. Once you and the victim are safe, then you can give first aid by first checking to see whether the victim is breathing and whether the heart is beating, because a person will die in just a couple of minutes without breathing and heartbeat. You then check for and control heavy bleeding. The next serious danger is poisoning, and you must treat for that if required. After that, take steps to prevent traumatic shock. Once these steps have been done, you have lessened the threat of death, and you have to study the situation and consider the victim's condition when deciding what to do next. The steps in this procedure will teach you what actions to take.

EQUIPMENT AND MATERIALS

- Resuscitation doll

  NOTE: Never practice CPR on a breathing person.

- Bleach solution (1 tablespoon bleach in 1 gallon of water)

  NOTE: Bleach solution on clean dressing should be used to clean resuscitation doll after each use.

- Clean dressings (prepared gauze, clean handkerchiefs, clean articles of clothing)

- Blankets
- Water and basin
- Rubbing alcohol
- Salt
- Cup or glass
- Sterile dressings (gauze pads and cotton)
- Splint material
- Strips of material for securing splints
- Towels

PROCEDURE

For adult victim of suspected cardiopulmonary arrest

NOTE: Cardiopulmonary arrest is a condition in which a person stops breathing and the person's heart stops beating. This condition can be caused by electrical shock, inhalation of toxic substances, severe injury, heart attack, and other circumstances.

1. Determine unresponsiveness

   a. Tap or gently shake victim's shoulder

   b. Shout, "Are you okay?"

      NOTE: This procedure is recommended as the person may be asleep.

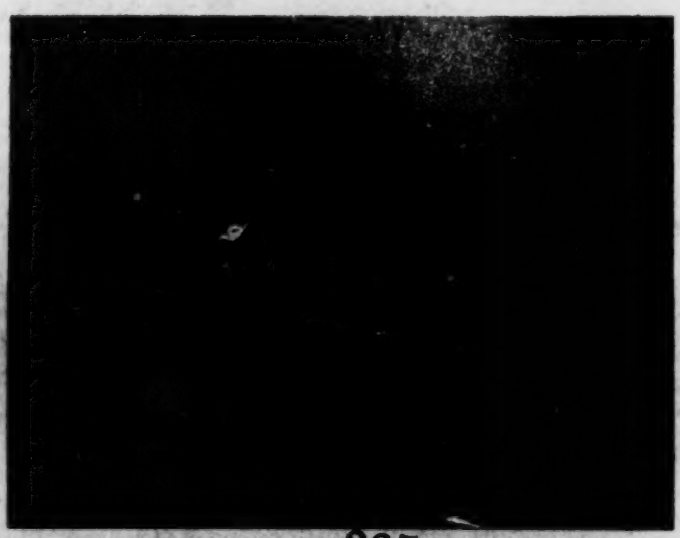
2. *If* victim remains unresponsive, call for help

   NOTE: Call out to alert bystanders so that they will know help is needed. If possible, indicate for a specific person to get help.

3. Position victim for cardiopulmonary resuscitation (CPR)

   a. Place victim flat on back, turning the whole body while supporting his or her head and neck (Figure 1)

FIGURE 1



b. Open victim's airway, using head-tilt/chin-lift maneuver—tilting back victim's head while lifting victim's chin (Figure 2)

NOTE: The head-tilt/chin-lift maneuver positions victim's tongue to prevent obstruction of the airway.

FIGURE 2

4. Check to see whether victim is breathing

   a. Use head-tilt/chin-lift maneuver to maintain open airway

   b. Place your ear over victim's mouth and observe the chest for movement while listening and feeling for breathing: look, listen, and feel (Figure 3)

FIGURE 3

5. *If* victim is **not** breathing, ventilate victim

CAUTION

Do **not** ventilate a breathing person.

a. Use head-tilt/chin-lift maneuver to maintain open airway

b. Pinch victim's nostrils shut (Figure 4)

NOTE: Pinching the victim's nostrils prevents air from escaping through the nose during ventilation.

FIGURE 4

c. Cover the victim's mouth with your mouth, making as airtight a seal as possible (Figure 5)

FIGURE 5

d. Ventilate by breathing into victim's mouth 2 times at a rate of 1 to 1 ½ seconds per breath, while watching for chest rise

CAUTION

Remove your mouth from the victim's mouth and allow victim's chest to deflate between ventilations.

6. Check for pulse

   a. Maintain head tilt with one hand on victim's forehead (See Figure 6)

   b. Using hand that was on victim's chin, feel for carotid pulse on near side of victim; take pulse for a full 5-second count (Figure 6)

FIGURE 6

7. *If* someone responded to call for help, send him or her to call for an ambulance; give local emergency number if known

8. *If* victim has no pulse, begin chest compressions

   a. Kneel beside victim's shoulders (Figure 7)

FIGURE 7

   b. Establish hand position (landmark)

      (1) Beginning at victim's side, locate bottom of rib cage (See Figure 8)

      (2) Run your fingers along bottom of rib cage and then up at center of rib cage to locate bottom of sternum—bone that connects the ribs (See Figure 8)

      (3) Measure 2 to 3 finger widths up from bottom of sternum to establish landmark (Figure 9)

FIGURE 8

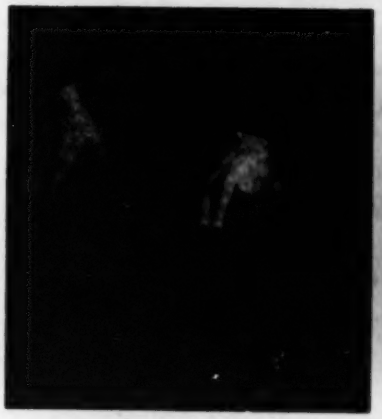


FIGURE 9

c. Position *heel* of one hand on landmark, place other hand on top, and interlace fingers (Figure 10)

CAUTION

Improper hand position can cause broken ribs, punctured lungs, and lacerated liver or spleen. Apply pressure with heel of hand only.

FIGURE 10

d. Deliver 15 compressions within 9 to 11 seconds, using the following guidelines

(1) Keep your shoulders over victim's sternum

(2) Keep arms straight

(3) Maintain an equal compression/relaxation ratio

(4) Compress victim's chest to a depth of 1 ½ to 2 inches

(5) Keep hands on victim's sternum during upstroke

(6) Relax pressure on victim's chest completely on upstroke

(7) Repeat a phrase such as "One and two and three and . . ." to maintain a rate of from 80 to 100 compressions per minute

9. Ventilate victim

   a. Use head-tilt/chin-lift maneuver to open airway

   b. Seal mouth and nose

   c. Deliver 2 ventilations at a rate of 1 to 1 ½ seconds per inspiration; watch for chest movement

   CAUTION

   Remove your mouth from the victim's mouth and allow victim's chest to deflate between ventilations.

10. Deliver 3 more sets of 15 compressions to 2 ventilations

11. Check pulse at carotid artery

12. *If* there is no pulse, continue CPR until there is pulse or medical help arrives

    a. Ventilate twice, watching for chest to rise

    b. Resume cycles of 15 compressions to 2 ventilations (Steps 8 and 9)

    c. Check carotid pulse every few minutes

13. *If* pulse is present, open airway and evaluate breathing

    a. Use head-tilt/chin-lift maneuver to open airway

    b. Look, listen, and feel for breathing

14. *If* victim is **not** breathing, perform ventilations at 12 times per minute, while monitoring pulse; continue ventilations until victim is breathing or medical help arrives

15. *If* victim is breathing, maintain open airway and monitor pulse and breathing until medical help arrives

    NOTE: Even if pulse is present and victim begins breathing, continue checking victim because cardiopulmonary arrest can recur.

PROCEDURE **For bleeding victim**

► WARNING ◄

Never remove a penetrating object from a wound as this could be fatal for the victim. Apply bulky dressing around the object as best as you can to stabilize the object. Direct pressure and elevation will stop bleeding from most wounds.

1. Apply a thick dressing (prepared gauze, clean handkerchiefs, clean articles of clothing) directly over wound, and press firmly with hand (Figure 11)

   NOTE: *If* no dressings are available, use your bare hand until a suitable dressing can be found.

FIGURE 11

2. Raise area of body with wound when you apply direct pressure *if* it does **not** cause victim pain and you do **not** suspect broken bones

3. Check dressing frequently to see whether bleeding has stopped or slowed

CAUTION

Do **not** disturb blood clots after they have formed. *If* blood soaks through dressing, do **not** remove dressing, but add more layers.

4. *If* bleeding is still active, apply a pressure bandage by holding the dressing in place with one hand, wrapping bandage directly over and around wound, and tying knot over wound; do **not** reduce pressure (Figure 12)

FIGURE 12

5. *If* bleeding continues, keep using direct pressure (and elevation when suitable), but also use a pressure point

CAUTION

Do **not** use a pressure point for an arm or leg wound unless direct pressure and elevation do **not** stop the bleeding.

6. When bleeding is under control, gradually release the pressure point

7. Treat victim to prevent traumatic shock

CAUTION

A victim may suffer shock, loss of consciousness, and even cardiopulmonary arrest from loss of blood. Because it is possible to bleed to death in a very short period of time, bleeding should be given urgent care.

8. Get medical help as soon as possible

PROCEDURE

For victim of poisoning

- Inhaled toxic gases, vapors, or mists

  1. Remove victim to source of fresh air

     ► WARNING ◄

     If the victim is in an enclosed area, do **not** attempt to rescue victim; call the fire department or rescue squad.

  2. While you attend to victim, direct someone to call an emergency squad

     NOTE: The person who calls the emergency squad must indicate the nature of the problem and explain that oxygen should be brought to the scene.

  3. Loosen victim's tight clothing

  4. *If* victim is unconscious, keep an open airway and give artificial respiration or CPR if indicated

  5. Save label from or container of suspected poison for identification

  6. Continue checking and assisting victim until medical help arrives

- Absorption or skin contact with harsh or corrosive substance

  1. Remove victim's contaminated clothing

  2. Immediately drench and flush affected skin with large quantities of water

  3. *If* poisoning is from corrosive substance, send for an ambulance immediately

  4. Continue washing all contaminated skin with soap and water for at least 5 minutes

  5. Keep victim's airway open and give artificial respiration if indicated

  6. Continue checking and assisting victim until medical help arrives

- Ingested poison

  1. Dilute poison by having victim drink a glass of water or milk *if* victim is conscious and **not** having convulsions and *if* ingested substance is **not** corrosive

     NOTE: Discontinue dilution if it makes victim nauseated. *If* victim does vomit, save a sample of the vomit for identification of the poison.

  2. Seek medical assistance by calling poison control center or a physician

     NOTE: You should post the poison control number for your region on your telephone. *If* you do not have the number, dial 0 or 911.

  3. *If* victim is unconscious, keep victim's airway open and give artificial respiration or CPR if indicated

  4. Save label from container of suspected poison for identification

  5. Continue checking and assisting victim until medical help arrives

PROCEDURE

For victim of traumatic shock

1. Keep victim lying down

2. *If* victim is bleeding from the mouth, place victim on one side so the blood will drain from mouth (Figure 13)

FIGURE 13

3. *If* victim feels faint, raise feet and legs—but *only if* moving the legs does **not** cause injury or pain (Figure 14)

FIGURE 14

4. *If* victim is having difficulty breathing, raise the head and shoulders (Figure 15)

CAUTION

Raising only the head may bend the neck and block the airway. Do **not** raise head and shoulders if you suspect a neck or back injury.

FIGURE 15

5. Cover victim to prevent loss of body heat

6. Give **no** drinks or foods

7. Get medical help as soon as possible

PROCEDURE

For victim of heat distress

- Heat stroke

  NOTE: Heat stroke is always a life-threatening situation. In heat stroke, the victim's temperature-control system, which causes sweating, stops working correctly. The body temperature rises so high that brain damage and death will result if the victim is not cooled quickly.

  1. Move victim out of sun, preferably to an air-conditioned room

  2. Cool the body immediately by soaking victim in cool but not cold water, sponging the body with rubbing alcohol or cool water, or pouring water on the body

  3. When victim's body temperature has been reduced to a safe level (about 102°F), stop cooling process and observe the victim for about 10 mintutes

  4. *If* temperature starts to rise again, cool the victim again

     NOTE: Use fans, air-conditioners, or fan by hand to circulate air and promote cooling. Do **not** give coffee, tea, or alcoholic beverages.

  5. Transport victim to hospital immediately

- Heat exhaustion

  1. Move victim out of sun, preferably to an air-conditioned room

  2. Loosen victim's clothing; apply cool, wet cloths; and fan to promote cooling

  3. Give *sips* of salt water (2 pinches of salt per glass of water) every 15 minutes for an hour

     CAUTION

     If victim is vomiting, give no fluids.

  4. Have victim remain lying down, and raise victim's feet 10 to 12 inches

5. Transport victim to hospital

NOTE: Medical care is needed for heat exhaustion.

- Heat cramps

CAUTION

If left untreated, the victim of heat cramps may develop heat stroke.

1. Move victim out of sun, preferably to an air-conditioned room
2. Have victim lie down
3. Apply firm pressure and warm, wet towels to cramped area
4. Give *sips* of salt water as for heat exhaustion
5. Have victim remain lying down, and raise victim's feet 10 to 12 inches

PROCEDURE

For burn victim

- First-degree burns
  1. Apply cold water or submerge burned area in cold water
  2. Apply a dry, sterile dressing to protect injury if necessary
- Second-degree burns
  1. Submerge burned area in cold water until pain eases, or apply cold, wet cloths

     CAUTION

     Do **not** use ice water.
  2. Blot dry gently with sterile dressing or clean, lint-free cloths
  3. Apply dry, sterile dressing, using care **not** to break blisters

     CAUTION

     Do **not** apply cream, ointments, sprays, or other substances to burn.
  4. Get medical help as soon as possible
- Third-degree burns
  1. *If* burning process has **not** stopped
     a. Remove any smoldering clothing

b. Immerse burned area in clean, cold water

CAUTION

Do **not** apply water to burn or immerse burn in water UNLESS burning process has not been stopped.

Immerse burned area for no more than 10 minutes. Prolonged immersion may cause life-threatening loss of body heat.

2. When burning process has stopped, cover burn with dry, thick, sterile dressing

3. Immobilize burned area as much as possible

4. Monitor victim's breathing and circulation

5. Treat to prevent traumatic shock

6. Transport victim to hospital as quickly as possible

PROCEDURE

For victim with foreign object or substance in eye

CAUTION

In an urgent-care situation involving a victim with an object or substance in the eye, flush the eye immediately with water from a water fountain or from a gently running hose or faucet. **Never** use a hose that is fitted with a power nozzle.

1. Wash hands

2. Explain procedure to victim

3. Position victim with affected eye lower than the good eye

   NOTE: This is done so that the contaminated fluid does not run from the affected eye to the good eye.

4. Moisten a sterile gauze pad with water, and clean any debris from eyelid *only if* there is no foreign object in eye

   CAUTION

   Always wipe from inner to outer side to prevent contamination. *If* you suspect a foreign object in the eye, do **not** press on the eyelid as that may cause the object to embed.

5. Use thumb and index finger to open eyelid

6. Flush eye by gently directing a stream of room-temperature water into inner side of eye

CAUTION

Do **not** touch the edge of the water container to the eye.

7. Flush eye for at least 15 minutes, especially if condition is caused by a caustic substance

8. Save flushed-out foreign object if this is what has caused the condition

NOTE: Medical personnel may need to see the object—note its shape and composition—when treating the injured eye.

9. Gently place sterile gauze pad over both eyes

10. Transport victim to hospital immediately

PROCEDURE

For victim with suspected fracture

- Closed fracture

1. Ask victim what happened and what hurts

2. Examine victim carefully

CAUTION

Do **not** move or have the victim move body parts that may be injured.

NOTE: After your initial examination, you will know whether an ambulance is needed. If such is the case, ask someone to call for an ambulance while you attend to the victim.

3. *If* you cannot get immediate medical help, immobilize the joints above and below suspected fracture with splints, taking care to move the bones as little as possible

NOTE: There are many types of splints available commercially; however, satisfactory emergency splints can be made from corrugated cardboard, newspapers, boards, straight sticks, or rolled blankets.

a. Choose or create a splint long enough to extend past the joints on either side of suspected fracture

b. Slide splints into place, taking care to move the bones as little as possible

c. Place padding (folded cloths, dressings, handkerchiefs, etc.) between splint and skin, especially over bony places

d. Hold splints in place with strips of cloth torn from clothing or with bandages, neckties, large handkerchiefs, or other suitable material

CAUTION

Do **not** cut off circulation by tying the cloth strips too tightly.

e. In fractures of the arm or leg, inspect fingers and toes often for swelling or bluish discoloration—signs that the bandages are too tight

f. Loosen bandages and reapply them *if* these signs appear

4. Elevate limb slightly to reduce hemorrhage and swelling

5. Treat to prevent traumatic shock

6. Transport victim to hospital if an ambulance is not needed

- Open fracture

NOTE: Open fractures are much more serious than closed fractures because of tissue damage and bleeding, the danger of infection, and the fact that the fracture area is always contaminated.

1. Remove or cut away victim's clothing in area of suspected fracture

2. Examine victim carefully

CAUTION

Do **not** move or have the victim move body parts that may be injured.

NOTE: After your initial examination, you will know whether an ambulance is needed. If such is the case, ask someone to call for an ambulance while you attend to the victim.

3. *If* bone fragment is **not** sticking out, control hemorrhage by applying pressure through a thick, sterile dressing over wound

CAUTION

Do **not** wash the wound, probe the wound, or insert your fingers in it.

4. *If* bone fragment *is* sticking out, cover entire wound with large, thick, sterile bandage compress or pads; *if* these are **not** available, use freshly laundered sheets or towels

CAUTION

Never attempt to set or reduce a fracture or try to push a protruding bone end back in place.

5. *If* you cannot get immediate medical help, apply splints as described for closed fractures

6. Elevate limb slightly to reduce hemorrhage and swelling

7. Treat to prevent traumatic shock

8. Transport victim to hospital if an ambulance is not needed

PRACTICAL TEST	DEVELOP FIRST-AID SKILLS

JOB SHEET 1

Perform first-aid treatment for simulated accident victims

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

For each simulated accident, the student:	YES	NO
1. Accurately evaluated emergency situation.	_____	_____
2. Accurately recalled sequence for giving first-aid actions.	_____	_____
3. Gave appropriate first-aid treatment.	_____	_____
4. Performed appropriate follow-up procedures (continued checking and assisting victim, obtained medical assistance, etc.).	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST	DEVELOP FIRST-AID SKILLS

Name _____ Score _____

OBJECTIVE 1

Choose the definitions that best define the following terms associated with first aid. Write the correct numbers in the blanks.

_____a. **First aid**

1. The use of self-adhesive bandages
2. Freedom from danger, risk, or injury
3. Immediate, temporary care given to the victim of an accident or sudden illness until the services of a physician can be obtained

_____b. **Resuscitation**

1. Act of reviving a person by bringing the person back to full consciousness
2. Any device, such as a bandage and stick, used to compress a blood vessel to stop bleeding or to control blood flow
3. Movement of the pistons in the cylinder of an internal combustion engine

_____c. **Traumatic shock**

1. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body
2. Heavy loss of blood
3. Unconsciousness due to a large dose of electricity

_____d. **Tourniquet**

1. Source of danger
2. Contest involving several teams
3. Any device, such as a bandage and stick, used to compress a blood vessel to stop bleeding or to control blood flow

_____e. **Hemorrhage**

1. Depressed condition of many of the body functions due to failure of enough blood to circulate through the body
2. Heavy loss of blood
3. Any device, such as a bandage and stick, used to compress a blood vessel to stop bleeding or to control blood flow

_____f. **Closed fracture**

1. Broken bone beneath the skin with no open wound
2. Broken bone associated with an open wound
3. Crack in a cylinder that extends above the highest point of piston travel

_____g. **Open fracture**

1. Broken bone beneath the skin with no open wound
2. Broken bone associated with an open wound
3. Crack in a cylinder that does not extend above the highest point of piston travel

OBJECTIVE 2

Arrange in order first-aid actions to follow in an emergency. Number the steps listed below in their correct order by writing a "1" beside the first step, a "2" beside the second step, and so on.

_____a. Control heavy bleeding

_____b. Seek medical help

_____c. Rescue victim and yourself

_____d. Prevent traumatic shock

_____e. Restore or maintain breathing and heartbeat

_____f. Treat for poisoning

_____g. Examine victim carefully to evaluate injury

_____h. Keep checking and assisting victim until medical help is obtained

OBJECTIVE 3

Determine pressure points to use to control bleeding. Read the following situations, and then on the drawing beside each situation indicate where the pressure should be applied. In each case, assume that the bleeding is heavy, that you have done all other first-aid steps required before controlling bleeding, and that you have tried direct pressure on the wound but the bleeding has continued.

a. A co-worker was standing in the engine compartment of a pickup adjusting the carburetor. He slipped and fell into the fan. You have turned off the engine and pulled him from the pickup. He is bleeding heavily from both legs and one hand. Where do you apply pressure to control bleeding from the wounds shown in the drawing?

b. Another mechanic jacked up a car without checking the procedure in the manufacturer's manual. The car fell on her. Fortunately, the full weight of the vehicle did not land on her, and her most serious injuries appear to be bad gashes in her face and shoulder. Where do you apply pressure to control bleeding from the wounds shown in the drawing?

OBJECTIVE 4

Select from the following list the symptoms of traumatic shock. Write an "X" beside each correct symptom.

Early stages

_____a. Very red skin

_____b. Moist, clammy skin if perspiration has occurred

_____c. General weakness

_____d. Slow pulse

_____e. Steady, slow breathing

_____f. Restlessness or anxiety

_____g. Vomiting or nausea

_____h. Sometimes severe hunger

Late stages

_____a. An attitude of not caring

_____b. Extreme alertness

_____c. Spotty or mottled appearance of skin

_____d. Sunken eyes with dilated pupils

_____e. Loss of consciousness, leading to death if untreated

_____f. High body temperature

OBJECTIVE 5

Classify burns according to their symptoms. Read the situations below, and determine what type of burns are described. Write a "1" in the space for a first-degree burn, a "2" for second-degree burn, and a "3" for third-degree burn.

_____a. An automotive technician spills gasoline all over his clothing and it ignites. His chest is badly burned, with a large patch of ash-looking flesh. The burn is well below the surface of surrounding skin, but the man does not seem to feel much pain.

_____b. A co-worker puts his hand on a hot exhaust manifold. His hand is red and swollen, and it hurts.

_____c. An automotive technician was removing a radiator cap when hot steam sprayed out on her. Her forearm is covered with blisters and is greatly swollen. She is in a great deal of pain.

_____d. An automotive technician was tightening a battery cable when he allowed the wrench to touch the other terminal. His palm has a wet-looking streak across it where the wrench had been. He feels a lot of pain and cannot close his hand.

OBJECTIVE 6

Read the following situations, and select the guidelines to follow for giving first-aid for each of the eye injuries described. Write an "X" beside the guidelines that should be followed in each situation. More than one guideline may be correct in each list of choices.

a. A technician is under a vehicle removing an exhaust pipe when rust flakes fall into her eye. What should you do?

_____1. Flush the eye with room-temperature water or solution designed for flushing eyes

_____2. Do not wash eye

_____3. Use clean, soft cloth to gently try to remove object

_____4. Do not try to remove object

b. A co-worker is drilling out a bolt that is stuck in an engine block. He is not wearing eye protection, and a piece of the bolt flies up and sticks in his eye. What should you do?

_____1. Flush the eye with room-temperature water or solution designed for flushing eyes

_____2. Do not wash eye

_____3. Use clean, soft cloth to gently try to remove object

_____4. Do not try to remove object

c. A technician carrying a battery trips over an extension cord and falls. Battery acid splashes up into his eyes. What should you do?

_____1. Flush the eye with room-temperature water or solution designed for flushing eyes

_____2. Do not wash eye

_____3. Use clean, soft cloth to gently try to remove object

_____4. Do not try to remove object

OBJECTIVE 7

For each of the following key words state the measure for preventing heat stroke, heat exhaustion, and heat cramps.

a. Fluids — _____

_____

b. Salt intake — _____

_____

c. Clothing — _____

_____

d. Head and face — _____

_____

e. Work breaks — _____

_____

f. Rest — _____

_____

OBJECTIVE 8

Read the situations below, and tell whether the victim described in each situation is suffering from heat stroke, heat exhaustion, or neither. Write an "S" in the blank for heat stroke, an "E" for heat exhaustion, or leave the space blank if neither heat stroke nor heat exhaustion is indicated.

_____a. One of your co-workers has been replacing a catalytic converter in an un-air-conditioned shop. After an hour or so, he gets out from under the car, sweating heavily. He says that he feels really tired and weak. He looks pale, and when you check his forehead, he does not seem to have a fever.

_____b. The wrecker driver for your shop has just towed a vehicle on a hot July day. He explains that the car lost a front wheel and had gone into a ditch and that he really had to work hard to get the car out. He says that the job gave him a headache, that, in fact, he feels dizzy and sort of sick to his stomach. He seems to have a fever. You check his pulse and notice immediately that his skin is hot. His pulse is about 140 beats per minute.

_____c. You stop by to visit a friend who is tuning up her car in a garage she uses for a shop. It is a hot day in August, but the shop has an evaporative cooler in one window. Your friend has kept the garage cool by running the cooler and keeping the doors and windows closed. When you enter, she is adjusting the engine speed, and she says that she has had trouble getting the idle speed right. She says that she feels dizzy and very tired. In fact, she feels sleepy despite getting a good night's sleep.

_____d. You are driving down the highway in August when you see a car with its hood up at the side of the road. You stop and find the driver angry and frustrated. He says that the car just quit on him and that he's been trying for almost an hour to get it started. You have started sweating almost as soon as you stepped out of the car, but the other driver isn't sweating at all. His skin is deep red and as you get near him you notice that he has strong body odor. A moment later, he passes out.

OBJECTIVE 10

Read the situations below and determine each victim's problem. Write the problem in the space provided and describe what actions should be taken for the problem.

a. One of your co-workers was getting some parts from a shelf when he slipped. He tells you that his right lower arm hurts. You check the arm and find that it is bent between the elbow and wrist. The arm is swollen and discolored. What is the problem, and how should it be treated?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

b. A customer's child wandered into the shop and drank some solvent from an open can. The child is conscious but feels sick. She still has the can in her hands when you find her. What is the problem, and how should you treat it?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

_____

c. Another worker in your shop slammed a car hood on his hand. The skin is broken and the hand is badly swollen, but there is little bleeding. You offer to take him to the hospital to get X-rays for broken bones. He doesn't seem to hear your question, and you notice that he looks pale. He says that he is dizzy and wants a drink. He seems to be breathing fast. What is the problem, and what should you do about it?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

d. You have gone boating with a friend of yours. The outboard motor stalls, and your friend pours gasoline in the carburetor to try to get it started. There is an explosion and a flash fire that quickly extinguishes itself. You check your friend and find burns on his face and right hand. The burned areas are red and spotty with some blistering and swelling. What is the degree of the burn, and what treatment is required?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

e. Your shop manager has stayed late at the shop to complete a exhaust system overhaul. Everyone else has left because the midsummer temperature is over 95°F (35°C), and the air-conditioning system is not working. When you return to the shop to pick up some of your tools, you find the shop manager unconscious under the car he was working on. His skin is very red and feels hot. He does not show signs of having sweated, but his body odor is strong. What is the problem, and what must be done?

Problem: _____

Treatment: _____

_____

_____

_____

_____

_____

_____

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine if additional training is needed.

WRITTEN TEST ANSWERS	DEVELOP FIRST-AID SKILLS

OBJECTIVE 1

a. 3
b. 1
c. 1
d. 3
e. 2
f. 1
g. 2

OBJECTIVE 2

a. 3
b. 7
c. 1
d. 5
e. 2
f. 4
g. 6
h. 8

OBJECTIVE 3

a.

b.

OBJECTIVE 4

Early stages b, c, f, g

Late stages a, c, d, e

OBJECTIVE 5

a. 3
b. 1
c. 2
d. 2

OBJECTIVE 6

a. 1, 3
b. 2, 4
c. 1

OBJECTIVE 7

a. Drink plenty of fluids
b. Increase salt intake
c. Wear lightweight clothing that allows sweat to evaporate
d. If outdoors, keep head and face shaded
e. Take frequent, short work breaks
f. Rest in shade or air-conditioned room whenever possible

OBJECTIVE 8

a. E
b. S
c. —
d. S

OBJECTIVE 10

a. Closed fracture
- Ask victim what happened and what hurts
- Examine victim
- Immobilize the wrist and elbow, elevate arm
- Treat for shock if required
- Transport to hospital

b. Ingestion of poison
- Have victim drink water or milk
- Call poison control center or a physician
- Save label from container
- Assist victim until medical attention is given

c. Traumatic shock
- Keep victim lying down
- Raise feet and legs if victim feels faint
- Raise head and shoulders to assist breathing
- Cover victim
- Do **not** give food or drinks
- Get medical help as soon as possible

d. Second-degree burns
- Submerge burned hand in cold water
- Apply cold, wet cloths to face
- Blot dry with sterile dressing or clean, lint-free cloths
- Apply dry sterile dressing, using care not to break blisters
- Get medical help as soon as possible

e. Heat stroke
- Move victim to cool place, preferably an air-conditioned room
- Cool the body with cool water or rubbing alcohol
- Observe victim for about 10 minutes
- Cool again
- Transport victim to hospital

OBJECTIVE SHEET

UNIT A-4 APPLY RELATED MATH AND MEASURING

INTRODUCTION

Often an automotive specialist must work with close-fitting parts such as pistons, bearings, and cams. Or, the specialist must determine an engine's horsepower, the amperage in a specific circuit, or the amount of piston displacement. In some situations, an automotive specialist may be called upon to calculate a customer's service charge, or to make change after a purchase or sale. Tools that a specialist uses will be sized in fractional or decimal units, and gauges and rules must be read. As you can see, an automotive specialist encounters math and measurement on a daily basis. Thus a complete understanding of basic mathematics is essential for the successful and skilled automotive specialist. The service specialist must be able to solve basic math problems and read precision measuring instruments.

UNIT OBJECTIVE

After completing this unit, the student should be able to solve basic math problems and read precision instruments. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit A-3, "Develop First-Aid Skills."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with math and measuring by choosing the correct definition from a list of three choices.

2. Determine the place values of a whole number by labeling the digits in a given whole number.

3. Add whole numbers. (Assignment Sheet 1)
4. Subtract whole numbers. (Assignment Sheet 2)
5. Multiply whole numbers. (Assignment Sheet 3)
6. Divide whole numbers. (Assignment Sheet 4)
7. Distinguish among types of fractions by writing a name for types of fractions.
8. Reduce fractions to lowest terms. (Assignment Sheet 5)
9. Convert mixed numbers to improper fractions and improper fractions to mixed numbers. (Assignment Sheet 6)
10. Add fractions. (Assignment Sheet 7)
11. Subtract fractions. (Assignment Sheet 8)
12. Determine the place values of a decimal number by labeling the digits of a given decimal number.
13. Add decimal numbers. (Assignment Sheet 9)
14. Subtract decimal numbers. (Assignment Sheet 10)
15. Multiply decimal numbers. (Assignment Sheet 11)
16. Divide decimal numbers. (Assignment Sheet 12)
17. Calculate correct amount of change due. (Assignment Sheet 13)
18. Convert fractions to decimals. (Assignment Sheet 14)
19. Recall the values of prefixes associated with metric measurement by writing the correct values for various metric terms containing the prefixes.
20. Read English and metric rules. (Assignment Sheet 15)
21. Recognize definitions of terms associated with circles by matching terms to their correct definitions.
22. Read standard and metric micrometers. (Assignment Sheet 16)
23. Use inside and outside micrometers. (Job Sheet 1)
24. Measure tire and wheel runout. (Job Sheet 2)
25. Estimate angle sizes. (Assignment Sheet 17)
26. Measure tire-tread depth. (Job Sheet 3)

SUGGESTED ACTIVITIES	APPLY RELATED MATH AND MEASURING

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Put up posters, charts, and signs. Have articles, specification guides, and remedial assignments available for student use. Have sets of flash cards available for student use.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

- Modify materials in unit or create supplementary materials for individual students as required.

DELIVERY

Unit Introduction

- Discuss introduction to the unit (see "Objective Sheet").

- Discuss the importance of math and measuring skills to the automotive specialist.

- Provide students with many examples of the math and measuring problems that the specialist is likely to encounter on a daily basis.

- Take students on a tour of the shop, pointing out tools, equipment, and vehicle components sized in decimal or fractional units. Introduce students to some of the measuring tools and equipment used in the trade.

- Discuss the ongoing shift in the automotive trade to the metric system. Provide students with current shop manuals so that they may see that specification charts, dimensions, and amounts are now given in metric units, often without English equivalents.

Objective 1 Recognize definitions of terms associated with math and measuring

- Use the chalkboard to show students examples or to demonstrate each term.

- Relate terms such as *ratio* to their use in the automotive service trades.

- When discussing the math processes (addition, subtraction, multiplication, and division), place an example of each on the chalkboard and label its component numbers as shown in example below.

EXAMPLE:

34,891	— Original number
x 11	— Multiplier
34891	— First partial product
34891	— Second partial product
383,801	— Product

Objective 2 Determine the place values of a whole number

- Play "You Inherit" with the students to help them learn the place values of a whole number. Ask students to tell you the least amount they inherit when you give them the amount in numbers of digits.

EXAMPLE: Q. You have just inherited a six-digit sum from your Uncle Elmore. What is the least amount you inherit?

A. One hundred thousand dollars.

Objective 3 Add whole numbers

- Discuss introductory material, explaining why a digit is carried in terms of place values.
- Prepare groups of objects such as fasteners, shop towels, bolts, wires, etc., to be added at different tables. Have students stop at each table and perform the addition required. Provide each student with a work sheet on which to write the equation and answer.
- Have students play dominoes. Score ends in multiples of three, five, six, or twelve; and have students play to a specified number of points.
- Have students play Scrabble, Tri-Ominoes, or any game that requires consistent addition to score.
- Make addition flash cards for the numbers 1 through 24. Have students use the flash cards with a team member or use the flash cards for group practice.

Objective 4 Subtract whole numbers

- Develop a set of flash cards containing various subtraction problems. Show students each card and have them give you the correct answer, either orally or written on a sheet of paper.
- Explain introductory material, and show students how to check their subtraction problems by adding the answer and subtracted number. Explain the principle of borrowing and its relationship to place values.
- Use spinner and game boards. Each student spins twice, writes down each number, subtracts the difference, and moves the marker the appropriate number of jumps.
- Have students practice subtraction by completing Supplement 1, "Substraction Squares."

  NOTE: You may want to prepare similar squares for addition, multiplication, and division with whole numbers, fractions, or decimals.

Objective 5 Multiply whole numbers

- Explain introductory material and work some problems on the chalkboard.
- Have students memorize Student Supplement 1, "Multiplication Table," as necessary.

- Develop a set of flash cards in which the numbers 1 to 12 are multiplied. Show students each card and have them give you the correct product, either orally or written on a sheet of paper.

- Quiz students on the multiplication tables.

- Have students sit in a circle. Have all students clap hands twice on legs, then clap hands together twice, then snap fingers twice to establish a rhythm that is to continue unbroken throughout the game. The caller gives the multiplication (or other operation) problem such as 8 × 6 while snapping fingers. At the next finger snapping, the caller says the name of someone to answer the problem. The responder gives the answer at next finger snapping without breaking the clap/snap rhythm. If the responder maintains the rhythm and gives the correct answer, then he or she becomes the next caller. If the responder breaks the rhythm or gives the wrong answer, then he or she is out of the game. The last person left is the winner.

Objective 6 Divide whole numbers

- Explain introductory material, working a number of sample problems on the chalkboard.

- Encourage students to make educated guesses. Often it is difficult for a student to break with a lifetime of training that demands precision and exactitude and frowns on guessing.

- For students who consistently cannot make appropriate decisions to solve long-division problems, try the decision-free, step-by-step procedure below. Use the chalkboard to work a number of problems in this manner.

a. Copy the problem.

b. Draw a vertical line to the right of the problem.

c. Make a guess and write that down to the right of the vertical line.

d. Multiply the guess by the divisor and subtract from the original number.

e. Repeat the process until subtracting produces a number smaller than divisor.

f. The answer is the sum of the guesses.

52)86310	
52000	1000
34310	
20800	400
13510	
10400	200
3110	
2600	50
510	
416	8
94	
52	1
42	1659

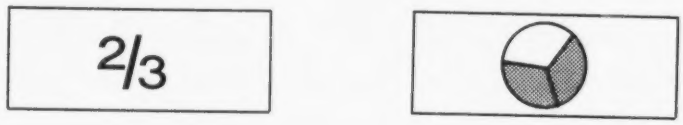
g. Check by multiplying the answer times the divisor and adding the remainder. If the problem has been solved correctly, the resulting sum should equal the original number inside the division frame.

EXAMPLE:	1659	Answer
	× 52	Divisor
	3318	
	8295	
	86,268	
	+ 42	Remainder
	86,310	Sum equal to original number

Objective 7 Distinguish among types of fractions

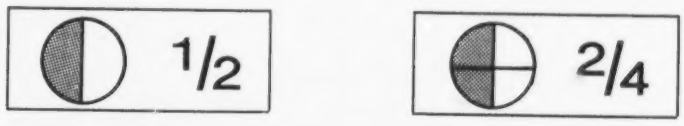
- Have students complete the "One step more..." exercise.
- Write a fraction, such as 3/8, on the chalkboard. Label the nominator and denominator. Explain that the denominator of this (or any) fraction represents the way that the unit has been split. Illustrate this by drawing a figure that has been divided into eight parts. Now explain that the numerator of this (or any) fraction represents the number of parts involved in a calculation. Therefore the fraction 3/8 indicates three parts of something that has been divided into eight parts. Shade in three of the eight parts on your illustration.
- Make two decks of cards. Show fractions on one deck and the corresponding pictures on the other deck.

  EXAMPLE:



  Cards can also be made to show equivalent fractions, using pictures and fractions.

  EXAMPLE:



  Students may play a game of matching or rummy by making pairs that match.

Objective 8 Reduce fractions to lowest terms

- Explain introductory material, working some problems on the chalkboard as examples.

- Divide the class into teams. Write two groups of fractions on the chalkboard to equal the number of students in each team. Have teams compete to see which can reduce their group of fractions to lowest terms first.

Objective 9 Convert mixed numbers to improper fractions and improper fractions to mixed numbers

- Have students measure various objects in the classroom: length of books, length and width of desk or table, height of chairs, length of pencil, etc. Have students record their measurements on a sheet of paper, and then have them convert their measurements into improper fractions. After they have the improper fractions, have them give their lists to another student, who then converts the improper fractions back to their mixed numbers.

Objective 10 Add fractions

- Discuss introductory material and work a number of problems on the chalkboard to demonstrate the steps in this math process.

- Prepare twenty-four tagboard flash cards. On each card, write two or three unlike fractions.

  EXAMPLES:

$1/2$ $3/8$ $3/4$	$3/5$ $2/3$ $1/6$

  Laminate the cards. Have students number their papers from 1 to 24; then give them fifteen seconds to write the least common denominator for the fractions on each flash card shown. To increase the difficulty, shorten the time-span for calculating each lowest common denominator.

- Use these flash cards to review addition, subtraction, and multiplication of fractions.

Objective 11 Subtract fractions

- Discuss introductory material and work a number of problems on the chalkboard to demonstrate the steps in this math process. Show how to subtract like fractions, unlike fractions, mixed numbers, and fractions from whole numbers.
- Make a set of flash cards such as those illustrated with the teaching suggestions for Objective 10. Use the flash cards to review subtraction of fractions.

Objective 12 Determine the place values of a decimal number

- Quiz students by having them write the following decimal numbers as you speak them.

  1. Two thousandths (.002)
  2. Three hundred fifty-two ten thousandths (.0352)
  3. Twelve thousandths (.012)
  4. One ten thousandths (.0001)
  5. Fourteen hundredths (.14)
  6. Nine hundredths (.09)
  7. Twenty-five ten thousandths (.0025)
  8. Two thousand one hundred and ten ten thousandths (.2110)

Objective 13 Add decimal numbers

- Explain introductory material and work a number of problems on the chalkboard.
- Assign a monetary value to each letter of the alphabet: A = $1.00, B = $1.50. . . Z = $13.50. Then have students calculate such problems as who has the most valuable name? What automotive specialty tool has the most valuable name? What piece of shop equipment has the most valuable name?

  NOTE: This activity can be adapted and used to practice multiplication of whole numbers and decimals and for practice with fractions.
- Have students look through a tool catalog, itemizing those tools that they would need for specific jobs designated by you (changing a tire, jacking up a vehicle, performing a lube job, etc.). Have students calculate the total cost of such tools.
- Have students compute total costs of parts, labor, and tax for repair service itemized on a work order.

- Give students an assortment of metric bolts and have them add the bolt-strength decimals.

Objective 14 Subtract decimal numbers

- Explain introductory material, emphasizing the importance of checking answers.
- Place a number of subtraction problems on the chalkboard and call on students to go to the board and solve the problems; or divide the class into teams and have the teams compete to see which can solve all of the problems first.

Objective 15 Multiply decimal numbers

- Explain introductory material, and work a number of problems on the chalkboard.
- Increase student speed in certain multiplication problems by giving timed tests in which the student must use the following shortcuts.

  To multiply by:

  5, 50, 500, etc., just multiply by 10, 100, 1000, etc., and divide by 2;

  25, 250, 2500, etc., just multiply by 100, 1000, etc., and divide by 4;

  33 1/3, 16 2/3, 12 1/2, 8 1/3, 6 1/4, multiply by 100 and divide by 3, 6, 8, 12, 16, respectively.

Objective 16 Divide decimal numbers

- Explain introductory material and work a number of problems on the chalkboard.
- Increase student speed in certain division problems by giving timed tests in which students use the following shortcuts.

  To divide by:

  3 1/3, multiply by 3 and divide by 10;

  33 1/3, multiply by 3 and divide by 100;

  16 2/3, multiply by 6 and divide by 100;

  25, multiply by 4 and divide by 100;

  50, multiply by 2 and divide by 100.

  NOTE: There are other shortcuts that you may want to add to this list and the list of multiplication shortcuts.

Objective 17 Calculate correct amount of change due

- Explain introductory material.

- Show Transparency 1, "Money Placement for Cash Drawer." Set up cash register and arrange money drawer properly:

  Coins in front row
  Pennies — First compartment on right
  Nickels — Second from right
  Dimes — Third from right
  Quarters — Fourth from right
  Halves — Fifth from right (or under drawer if it has only four slots)

  Bills in back row
  $1 — First long compartment on right
  $2 — Under drawer
  $5 — Second long compartment from right
  $10 — Third long compartment from right
  $20 — Fourth long compartment from right
  $50, $100, checks — Fifth long compartment from right (or under drawer)

  Have students watch you set up the drawer. Explain that there is no compartment for $2 bills and that $50 bills and $100 bills are kept under the drawer to avoid mixing them with the other bills and giving them in error. Also show students that bills should be placed in the drawer straightened out, face up, with top of bill to right so that the cashier can quickly determine the denominations.

- Demonstrate how to make a complete customer transaction. Allow each student to return the demonstration.

- Divide class into teams to solve the following change-making problems:

$21.19 out of $40.00	$11.63 out of $15.00
$15.29 out of $20.00	$25.42 out of $50.00
$ 3.63 out of $20.00	$19.24 out of $50.00
$32.67 out of $40.00	$ 2.69 out of $20.00
$28.36 out of $40.00	$41.01 out of $50.00

Objective 18 Convert fractions to decimals

- Provide students with copies of Student Supplement 2, "Metric and Customary Decimal Equivalents for Fractional Parts of an Inch." Encourage them to memorize part or all of chart on decimal equivalents.

- Before presenting rules for converting fractions to decimals, have students solve problems by converting the decimals to fractions. The answer from the computation with the equivalent fractions must then be converted back to decimal form. Half a dozen exercises like this for each decimal rule may help students appreciate the benefits of learning decimal rules and why they work.

EXAMPLE: $5.67 + 3.2 + 4.104 = 5\frac{670}{1000} + 3\frac{200}{1000} + 4\frac{104}{1000}$

$$= 12\frac{974}{1000}$$

$$= 12.974$$

- Obtain a quantity of pocket-sized decimal-equivalent charts from your local tool supplier. Give one to each student.

Objective 19 Recall the values of prefixes associated with metric measurement

- Use Transparency 7, "Reading Decimal Inches," to explain measuring with a metric rule.

- Give numerous examples of each prefix as related to the automotive trade.

  EXAMPLES: Sizes and torque specifications for metric nuts and bolts, service schedules specifying kilometers, high-pressure compressor cut-off switches that measure pressure in kilopascals (kPa), tubing sizes, fluid capacities, etc.

- Explain Student Supplements 2 and 3, "Metric and Customary Decimal Equivalents for Fractional Parts of an Inch" and "Metric/Customary Conversion Table," and then have students complete Activity Sheet 2, "Compute English/Metric Equivalents." Critique the practice sheet in class.

- Have students look through a shop manual to find instances in which metric measurements are used.

Objective 20 Read English and metric rules

- Explain introductory material, using Transparencies 2 through 8 to illustrate your explanation.
- Provide students with various metric and English rules. Have students work as teams reading each other's rules.
- Have students use an English rule and then a metric rule to measure items around the shop such as the diameter of a drum, carburetor float level, width of a brake, clutch-pedal free travel, the diameter of clutch or pressure plate, etc.

Objective 21 Recognize definitions of terms associated with circles

Objective 22 Read standard and metric micrometers

- Discuss and explain introductory material, using the chalkboard to illustrate your points.
- Show students different-sized inside and outside micrometers and name the parts of each.
- Have students practice using an outside micrometer to measure appropriate objects in the shop such as camshaft diameter, piston diameter, rotor thickness, crankshaft rod and main journal, thickness of thrust washer, etc.
- Have students practice using an inside micrometer to measure appropriate objects in the shop such as engine cylinder bores, inside of automatic transmission, or any other inside diameter.
- Review place values of decimal numbers if necessary.

Objective 23 Use inside and outside micrometers

- Demonstrate the procedures in the job sheet.
- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 24 Measure tire and wheel runout

- Demonstrate the procedures in the job sheet.
- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 25 Estimate angle sizes

- Explain that in the automotive service trade, estimating angle sizes is important because the automotive specialist is often instructed to hold a tool at a specified angle or to install a part at such-and-such an angle. Thus, the student must be able to estimate angle sizes.
- Explain the introductory material and use chalkboard to present additional problems for student computation.

Objective 26 Measure tire-tread depth

- Demonstrate the procedures in the job sheet.
- Have students practice job-sheet procedures until they are ready to take the practical test.

Activity Sheets 1 through 3

- Discuss with class the purpose of each activity sheet. The purpose of Activity Sheet 1, "Work with Fractions," is to give the students additional work with fractions. The purpose of Activity Sheet 2, "Compute English/Metric Equivalents," is to give students additional work in English/metric conversions, and the purpose of Activity Sheet 3, "Complete Credit Card Transactions," is to teach the students how to accept credit card payments and complete sales drafts.

EVALUATION

- Give written test.
- Give practical tests, and evaluate test on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Klewer, Edward D. *Making Basic Math Skills Work for You in Marketing.* Austin: University of Texas, 1983.
- Litton, Bill, and James Sharpton. *Introduction to Auto Body.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1985.
- Olivo, C. Thomas, and Thomas P. Olivo. *Basic Vocational-Technical Mathematics,* 5th ed. Albany, New York: Delmar Publishers, 1985.

- Smith, Robert D. *Vocational Technical Mathematics.* Albany, New York: Delmar Publishers, 1983.
- State of Florida Department of Education. *Introduction to Automotive Mechanics, Unit 1: Hand Tools, Automotive Fasteners, Shop Equipment, and Supplies.* Tallahassee, Florida: State of Florida Department of Education, 1982.
- Treff, August V., and Donald H. Jacobs. *Basic Mathematics Skills.* Baltimore: Media Materials, Incorporated, 1982.
- Western Maryland Vocational Resource Center. *Cash, Coins, and Credit Cards,* Packet Four. Cresaptown, Maryland: The Maryland Vocational Curriculum Production Project/Western Maryland Vocational Resource Center, 1978.
- U.S. Office of Health, Education, and Welfare. *Basic Mathematics.* Washington, D.C.: Distributive Education Branch of U.S. Office of Health, Education, and Welfare, 1973.

Media

- *Use Plain Micrometer*
- *Use Inside Micrometer*
- *Check Tire and Wheel Runout*

NOTE: The videotapes listed above are available on a free-loan basis to Oklahoma teachers from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

Print media

- Sample work orders so that students can practice completing the forms and computing hours, parts, and costs involved in specific service situations
- Credit cards, sales drafts, warning bulletins, and an imprinter so that students may complete Activity Sheet 3, "Complete Credit Card Transactions"
- State and city tax tables so that students may practice multiplying decimals and may use as reference for completing sales drafts in Activity Sheet 3
- Supply of 3 x 5 cards on which to print math processes for use as flash cards, or purchased sets of flash cards

- Transparencies and competency profiles

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

Equipment

- Cash register with change drawer and play money in the following amounts and denominations:

4 $20.00 bills	$ 80.00
4 $10.00 bills	40.00
4 $ 5.00 bills	20.00
5 $ 1.00 bills	5.00
50 pennies	.50
20 nickles	1.00
10 dimes	1.00
6 quarters	1.50
4 half dollars	2.00
	$151.00

- Measuring instruments and equipment and materials necessary for completion of job sheets

Books from which to draw additional assignments and teaching suggestions

- *Math*, available from the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

  NOTE: This manual covers seven areas of instruction and contains assignment sheets specifically designed to acquaint students with basic practical mathematics problems and terms directly related to vocational skill trades, including auto mechanics. The guide contains instruction in measurement, whole numbers, fractions, decimals, percentages, consumer education, and geometry.

- *Speaking of Numbers*, available from the Institute of Modern Languages, 2622 Pittman Drive, Silver Spring, Maryland 20910.

  NOTE: While this self-instructional workbook/textbook series is intended for use with beginning English-as-a-second-language students, it can also be used with native speakers of English who require remediation and reinforcement in numbers and arithmetic operations.

- *Cash, Coins, and Credit Cards*, available from The Maryland Vocational Curriculum Production Project, Western Maryland Vocational Resource Center, P.O. Box 5448, McMullen Highway, Cresaptown, Maryland 21502, (301) 777-5886.

  NOTE: This booklet is part of a series on automotive servicing. It tells the student how to accept payment and fill out credit card slips, and it contains useful learning activities.

INSTRUCTOR'S SUPPLEMENTS	APPLY RELATED MATH AND MEASURING

SUPPLEMENT 1

Subtraction Squares

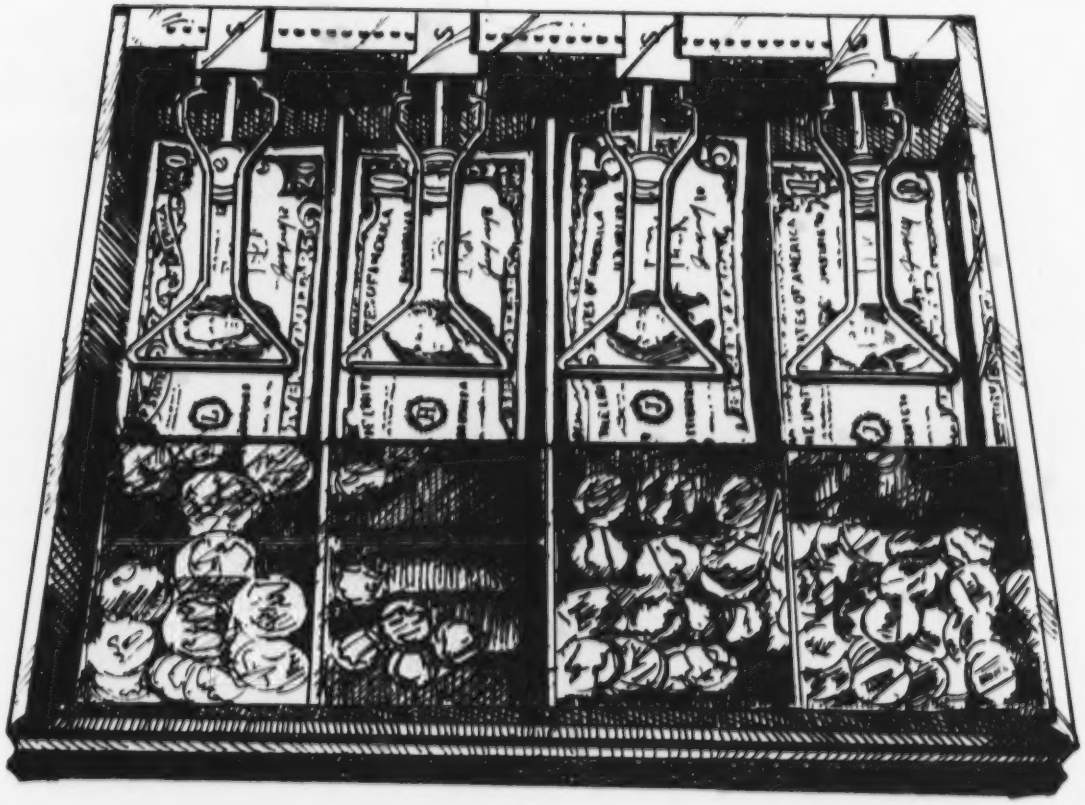
Cut out the sixteen squares shown below and then fit them together so that the edges that touch form a problem and its correct solution. For better durability, glue the sheet to heavy poster board before cutting out squares.

10−5 6 9−1 8−1	8 10−7 15−5 12−2	9−4 5	11−2 2
6 6−2 12−6 10−2	7 10 6−4 9−6	4−0 7	0 12−3
7−4 2 4	3 10−6 9−2	10 8−3 4	4 3 5
9 8 3	1 8−8 5	9 7−6 9−3	8−6 4 7−3

Solution to Supplement 1

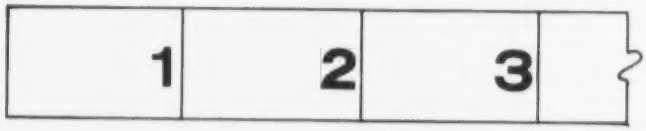
11–2 2	9 7–6 9–3	1 8–8 5	0 12–3
8–6 4 7–3	6 6–2 12–6 10–2	10–5 6 9–1 8–1	9 8 3
4 3 5	8 10–7 15–5 12–2	7 10 6–4 9–6	7–4 2 4
9–4 5	10 8–3 4	3 10–6 9–2	4–0 7

Money Placement for Cash Drawer

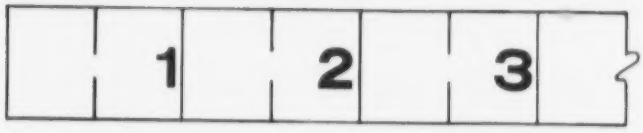


Graduations on a Rule

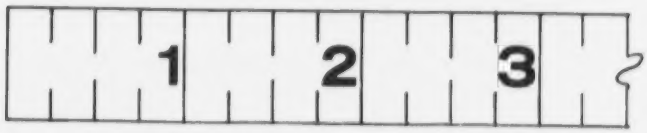
Inches



Halves



Quarters or Fourths



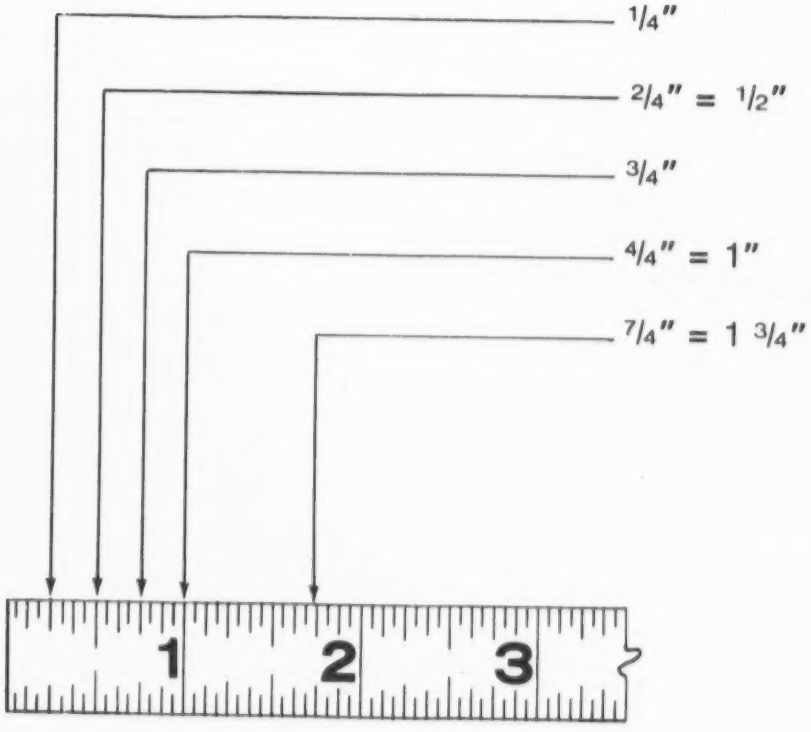
Graduations on a Rule
(Continued)

Eighths

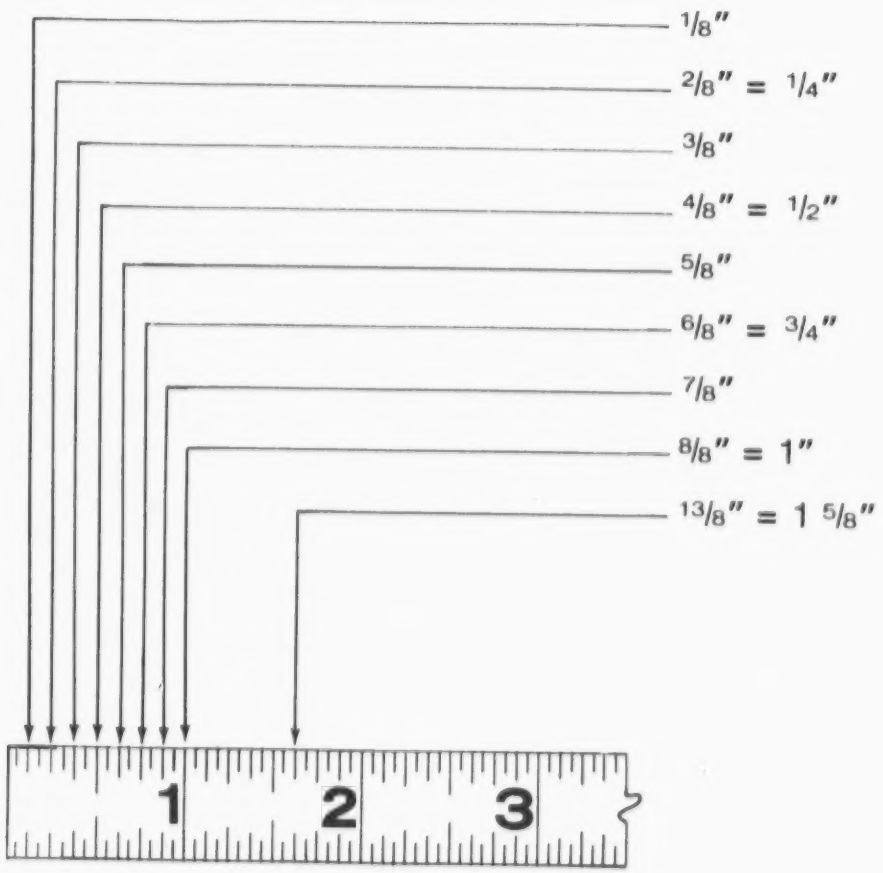
Sixteenths

Thirty-Seconds

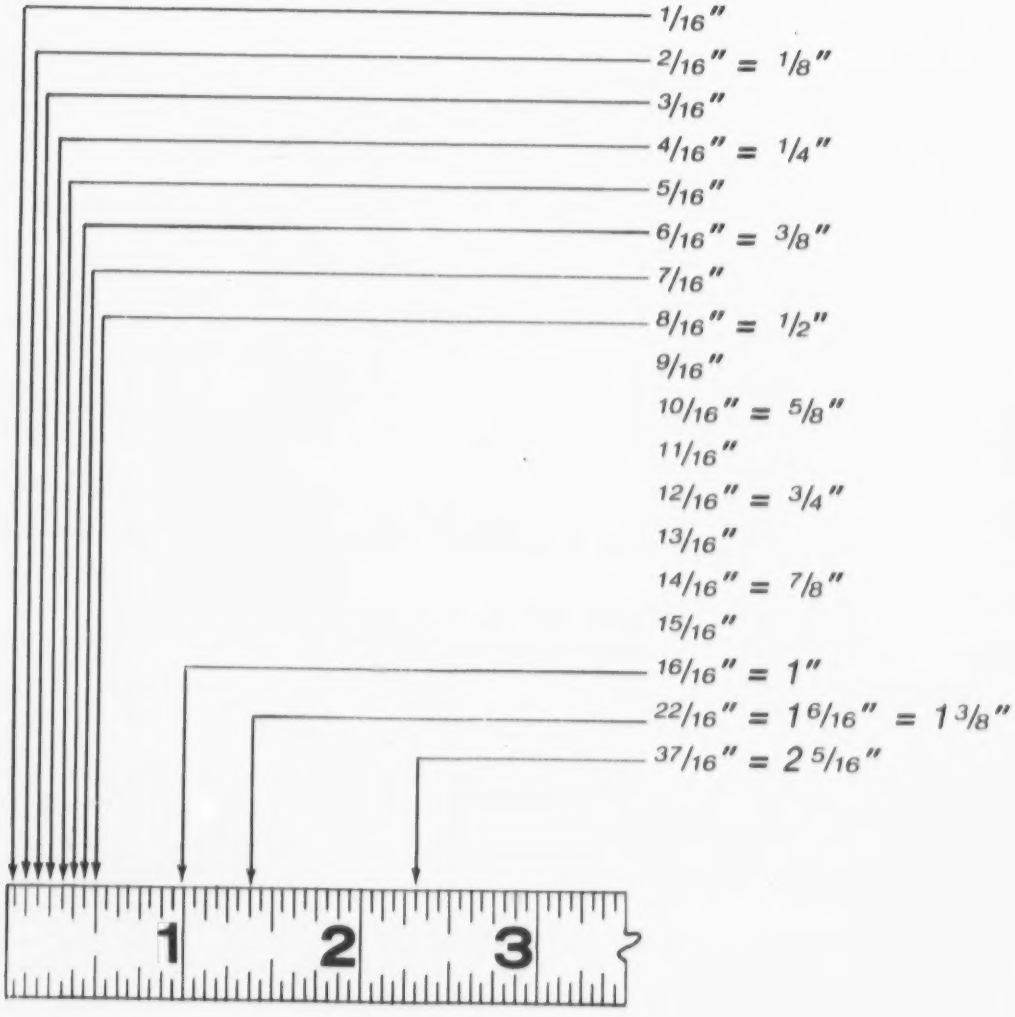
Reading Fourths on a Rule



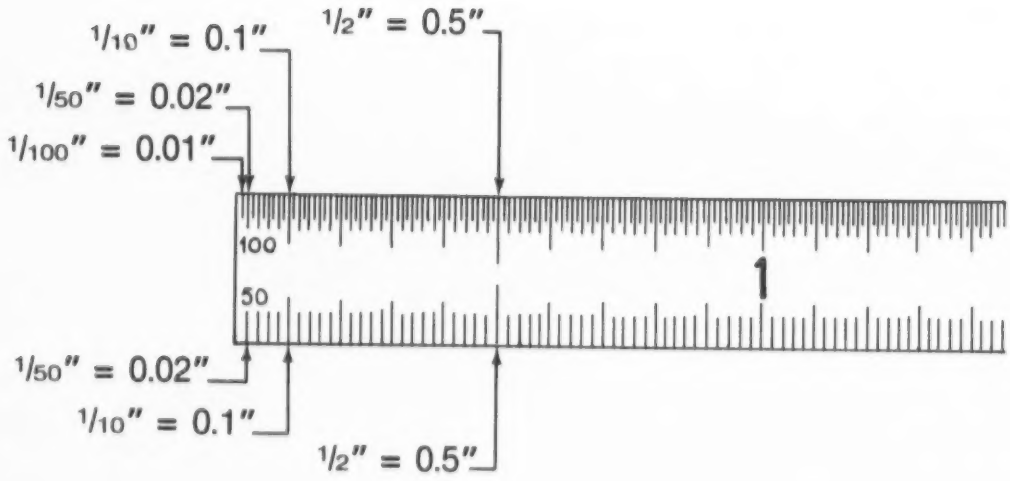
Reading Eighths on a Rule



Reading Sixteenths on a Rule

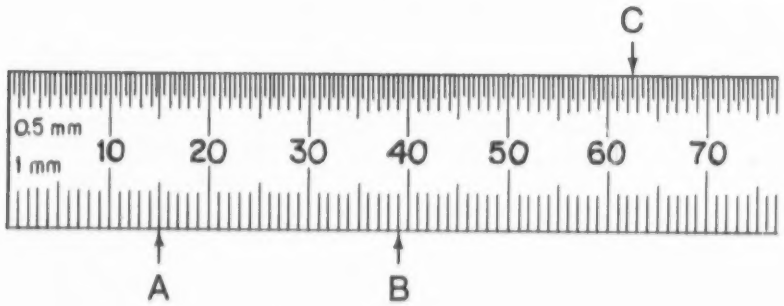


Reading Decimal Inches



English rule with decimal graduations in fiftieths and one hundredths

Reading Measurements on a Metric Rule



Metric rule with 1-mm and 0.5-mm graduations

Read the measurement to reference point A.

The measurement to reference point A is 10 mm plus 5 mm.
A = 10 mm + 5 mm = 15 mm.

Read the measurement to reference point B.
The measurement to reference point B is 1 mm less than 40 mm.
B = 40 mm – 1 mm = 39 mm.

Read the measurement to reference point C.
The measurement to reference point C is 60 mm plus two 1-mm graduations plus one 0.5-mm graduation.
C = 60 mm + 2 mm + 0.5 mm = 62.5 mm.

PRETEST ANSWERS

APPLY RELATED MATH AND MEASURING

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 2
2	3
3	17, 36c, 36d
4	18, 36a, 36b
5	19, 36e, 36s
6	20, 36f, 36g
7	4
8	23
9	21, 22
10	25, 36i, 36j, 36k
11	24, 36l, 36m, 36n
12	5
13	26, 36o, 36p
14	27, 36q, 36r
15	31, 36s, 36t, 36u
16	28, 36v, 36w, 36x
17	35
18	29, 30
19	8, 9, 14
20	32, 33
21	6, 7
22	15, 16, 34
23	34
24	12
25	11
26	10, 13

ANSWER KEY

PART 1—Multiple choice

1. a
2. a
3. b
4. b
5. a
6. a
7. c
8. c
9. b
10. a
11. b
12. b
13. c
14. a
15. c
16. b

PART 2—Problem solving

17.	a. 1538	b. 2187	c. 16,430
18.	a. 283	b. 1175	c. 1810
19.	a. 21,291	b. 165,478	c. 503.605
20.	a. 20 5/12	b. 180 5/23	c. 3 317/373
21.	a. 1 4/5	b. 1 7/16	c. 2 1/8
22.	a. 37/8	b. 31/4	c. 297/32
23.	a. 1/2	b. 1/2	c. 3/8
	d. 1/2		
24.	a. 3/8	b. 9/16	c. 1/16
25.	a. 1/2	b. 1	c. 29/32
	d. 1 3/16		
26.	a. $71.01	b. $131.32	c. $9.22
27.	a. $749.25	b. 508.16	c. 197.802
	d. $4.15		
28.	a. 14,000	b. 33	
29.	a. 0.125	b. 0.75	c. 0.50
30.	a. 63.9	b. 38.95	c. 105.034
31.	a. 297.5	b. 100.32	c. 0.448
32.	a. 15/16	b. 3 5/16	
33.	a. 5 mm	b. 37 mm	c. 50.5 mm
34.	a. Ratchet	b. Thimble	c. Sleeve
	d. Spindle		

35.

	Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	Total returned
a.	$2.77 out of $5.00	3		2			2		2.23
b.	$1.29 out of $10.00	1		2		1	3	1	8.71
c.	71¢ out of $10.00	4			1		4	1	9.29

36.

a. 948	b. 38	c. 17
d. 1135	e. 315	f. 104
g. 11	h. 3000	i. $7\frac{3}{4}$
j. $8\frac{1}{4}$	k. $7\frac{3}{16}$	l. $\frac{1}{8}$
m. $2\frac{3}{4}$	n. $\frac{1}{16}$	o. 74.33
p. 41,018.26	q. $3317.32	r. 14.5
s. $6187.50	t. $132.62	u. $348
v. $19	w. $54	x. 8.2

PRETEST

APPLY RELATED MATH AND MEASURING

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then solve each problem or choose the item that best answers the question or solves the problem. Write your answers in the blanks provided.

PART 1 — Multiple choice

_____1. Which of the following is the best definition for the term *whole number (integer)*?

a. Any of the natural numbers, both positive and negative, that represent a complete item
b. Any of the ten symbols, 0 to 9, by which all numbers can be expressed
c. A positive or negative number that represents a complete item

_____2. A relationship in quantity, amount, or size between two or more things is called a

a. Ratio
b. Decimal
c. Percent

_____3. What is the place value of the number *8* in the number 4,380,954?

a. Thousands
b. Ten thousands
c. Hundred thousands

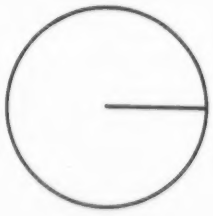
_____4. Which of the following types of fractions is $^9/_8$?

a. Proper fraction
b. Improper fraction
c. Mixed number

_____5. What is the place value of the number 5 in the decimal number 0.5843?

a. Tenths
b. Hundredths
c. Ten thousandths

_____6. The line drawn in the circle below is called a



a. Radius
b. Diameter
c. Circumference

_____7. There are _____ degrees in a circle.

a. 180
b. 300
c. 360

_____8. The prefix *milli* when added to metric units of measurement means

a. One tenth
b. One hundredth
c. One thousandth

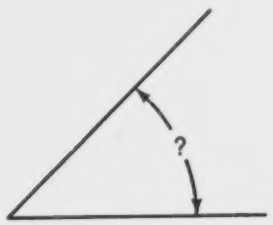
_____9. The prefix *deci* when added to metric units of measurement means

a. One thousand
b. One tenth
c. One hundredth

_____10. A tire should be replaced when the remaining tread thickness measures less than

a. 1/16 inch
b. 3/16 inch
c. 4/32 inch

____11. Approximately how many degrees are there in the angle below?



a. 90
b. 45
c. 10

____12. Technician A says that when checking tire and wheel runout, the check should not be made until the tires have had time to "set" after standing for a period of time. Technician B says that to check tire and wheel runout properly, the vehicle should be driven several miles to heat the tires, and then raised and supported on jack stands.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

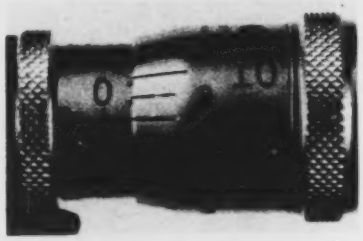
____13. Which piece of equipment listed below is used to measure tire-tread depth?

a. Runout gauge
b. Tire gauge
c. Tread-depth gauge

____14. The prefix *kilo* when added to metric units of measurement means

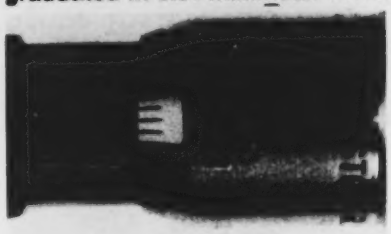
a. One thousand
b. One hundred
c. Ten

____15. What reading is shown on the English micrometer graduated in 0.001-inch increments illustrated below?



a. 0.83"
b. 0.84"
c. 0.083"

____16. What reading is shown on the metric micrometer graduated in 0.01-millimeter increments illustrated below?



a. 5.16 mm
b. 5.69 mm
c. 6.19 mm

PART 2 — Problem solving

17. Solve each of the following addition problems.

a.	b.	c.
341	742	9876
428	564	5432
+ 769	+ 881	+ 1122

18. Solve each of the following subtraction problems.

a.	b.	c.
981	1420	3459
- 698	- 245	- 1649

19. Solve each of the following multiplication problems. Show your work in the space provided.

a. $\begin{array}{r} 453 \\ \times\ 47 \\ \hline \end{array}$ b. $\begin{array}{r} 314 \\ \times\ 527 \\ \hline \end{array}$ c. $\begin{array}{r} 2143 \\ \times\ 235 \\ \hline \end{array}$

20. Solve each of the following division problems. Show your work in the space provided. Express your remainders as reduced fractions.

a. $12\overline{)245}$ b. $46\overline{)8290}$ c. $746\overline{)2872}$

21. Convert each of the following improper fractions to mixed numbers. Show your work in the space provided.

a. $^{9}/_{5}$ = _____ b. $^{23}/_{16}$ = _____ c. $^{17}/_{8}$ = _____

22. Convert each of the following mixed numbers to improper fractions. Show your work in the space provided.

a. $4\ ^{5}/_{8}$ = _____ b. $7\ ^{3}/_{4}$ = _____ c. $9\ ^{9}/_{32}$ = _____

23. Reduce each of the following fractions to their lowest terms.

a. $^{4}/_{8}$ = _____ b. $^{8}/_{16}$ = _____

c. $^{9}/_{24}$ = _____ d. $^{16}/_{32}$ = _____

24. Find common denominators and subtract the following fractions. Show your work in the space provided.

a. $3/4 - 3/8 =$ _____

b. $15/16 - 3/8 =$ _____

c. $1/2 - 7/16 =$ _____

25. Find common denominators and add the following fractions. Reduce to lowest terms. Show your work in the space provided.

a. $1/4 + 2/8 =$ _____ b. $4/16 + 3/4 =$ _____

c. $3/4 + 5/32 =$ _____ d. $7/8 + 5/16 =$ _____

26. Add each of the following decimal numbers. Show your work in the space provided.

a. \$8.87 + \$62.14 = _____ b. \$34.87 + \$96.45 = _____

c. \$4.60 + \$4.62 = _____

27. Subtract each of the following decimal numbers. Show your work in the space provided.

a. \$815.23 – \$65.98 = _____ b. 567.94 – 59.78 = _____

c. 198 – .198 = _____ d. \$20.03 – \$15.88 = _____

28. Divide each of the following decimal numbers. Show your work in the space provided.

a. 406 ÷ 0.029 = _____ b. 19.8 ÷ 0.6 = _____

29. Express each of the following fractions as a decimal.

a. $^1/_8$ = _____ b. $^3/_4$ = _____ c. $^1/_2$ = _____

30. Write decimal equivalents for each of the following mixed numbers.

a. $63\ ^9/_{10}$ = _____ b. $38\ ^{95}/_{100}$ = _____

c. $105\ ^{34}/_{1000}$ = _____

31. Multiply each of the following decimal numbers. Show your work in the space provided.

a. 35 × 8.5 = _____ b. 26.4 × 3.8 = _____

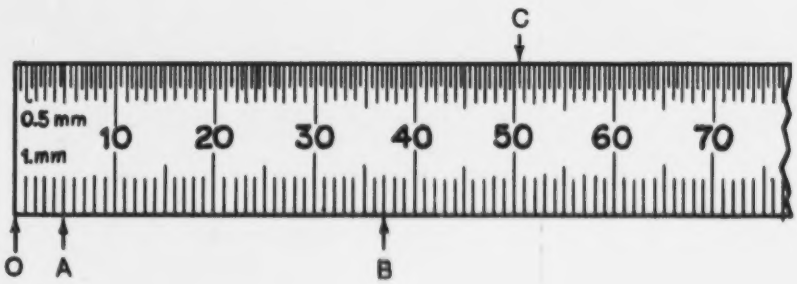
c. 0.08 × 5.6 = _____

32. Read the rule illustrated below to the nearest sixteenth inch. Write your answers in the blanks provided.

a. 0 to A = _____

b. 0 to B = _____

33. Read the metric rule illustrated below to the nearest 0.5 millimeter. Write your answers in the blanks provided.

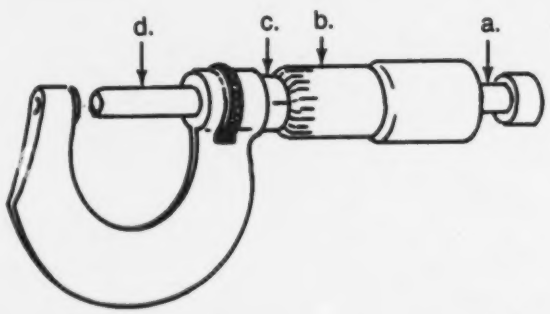


a. 0 to A = _____

b. 0 to B = _____

c. 0 to C = _____

34. Name the parts of the outside micrometer indicated on the illustration below. Write your answers on the blanks.



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a. _____

b. _____

c. _____

d. _____

35. Calculate the correct change for the following problems. Use as few coins and bills as possible, and enter the number of coins and bills only.

Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	Total returned
a. $2.77 out of $5.00								
b. $1.29 out of $10.00								
c. 71¢ out of $10.00								

36. Solve the following story problems. Write your answers in the blanks.

_____a. In the first year of operation, an automotive shop handled 1219 jobs. During the second year, the number of jobs increased to 2167. How many more jobs did the shop handle the second year?

_____b. To repair the brakes on a late-model automobile takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

_____c. An automotive specialist has 9 thermostats for replacement when needed. He has ordered and received 8 additional thermostats from the local parts store. How many total thermostats does he have in stock?

_____d. An automotive specialist ordered the following number of bolts at different dates: 256, 62, 575, and 242. How many bolts should she be billed for?

_____e. It takes 35 minutes to change the oil and replace the filter on one vehicle. How many minutes does it take to perform the same job on 9 vehicles?

_____f. How many 4-liter oil changes can be made using cases containing 416 liters of oil?

_____g. If a can of lubricant holds 5 pounds, how many cans may be filled from a 55-pound drum?

_____h. There are 500 bolts in a box. How many are in 6 boxes?

_____i. What is the combined length of two bolts that measure 3 1/2 inches and 4 1/4 inches?

_____j. Tom worked 4 1/2 hours before lunch and 3 3/4 hours after lunch. How many hours did Tom work?

_____k. What is the combined length of three extension tools measuring 2 1/8 inches, 3 1/4 inches, and 1 13/16 inches?

_____l. Bill had a 7/8-inch wrench. He needed a 3/4-inch wrench. How much difference is there in the size of the wrenches?

_____m. 5 1/4 hours are how many more than 2 1/2 hours?

_____n. If you had to reduce a 15/16-inch part by 7/8 inch, how much would you have to reduce it?

_____o. On a repair job, labor costs $54.65, parts cost $16.30, and tax costs $3.38. What is the total cost of the job?

_____p. In one month, an auto shop had the following expenses: engine parts, $286.96; transmission parts, $142.37; electric bill, $160.16; telephone, $116.27; and labor, $40,312.50. What was the shop's monthly expenditure?

_____q. An auto shop received $8438.64 this month and paid out $5121.32. How much profit did the shop make?

_____r. It takes 20.5 hours to finish a job. Mary has worked 6 hours. How many hours will it take her to finish the job?

_____s. The average cost of a replacement part is $41.25. During the year, the technician installs 150 such parts. What was the total cost?

_____t. A specialist buys 38 fasteners at a cost of $3.49 each. What is the total cost?

_____u. If a can of lubricating grease costs $6.00 per pound, how much will 58 pounds of grease cost?

_____v. Sam received $361.00 for an engine overhaul job. He worked 19 hours on the job. How much did he make per hour?

_____w. An apprentice mechanic is paid $729.00 for 13.5 weeks of work. Find the average earnings per week for the apprentice.

_____x. If battery service can be performed on 32 vehicles in 3.9 days, how many vehicles can be serviced in 1 day? Round your answer to the nearest tenth.

INFORMATION SHEET

APPLY RELATED MATH AND MEASURING

OBJECTIVE 1

Recognize definitions of terms associated with math and measuring

Whole number (integer) —Any of the natural numbers, both positive and negative, that represent a complete item

EXAMPLE: 25 is a whole number as opposed to 3/4, a fraction or part of a whole.

Digit — Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

Fraction — Part of a whole; represents one or more equal parts of a unit (Figures 1 and 2)

EXAMPLES: 1/2, 3/8, 1/4, 3/16

FIGURE 1

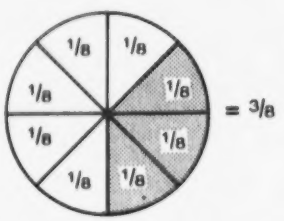
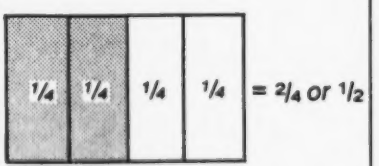


FIGURE 2



Decimal — Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

EXAMPLE: 0.1 = 1/10 0.06 = 6/100 0.003 = 3/1000

Addition — Process of totaling two or more numbers to find another number called a *sum*

EXAMPLE: 3 + 5 + 9 = 17

Subtraction — Opposite operation of addition

EXAMPLE: 8 – 4 = 4 as opposed to 4 + 4 = 8

Multiplication — Abbreviated process of adding a number to itself a specified number of times

EXAMPLE: 6 x 3 = 18 as opposed to 6 + 6 + 6 = 18

Division — Opposite operation of multiplication

EXAMPLE: $16 \div 2 = 8$ as opposed to $8 \times 2 = 16$

Percent — One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

Ratio — Relationship in quantity, amount, or size between two or more things

Meter — Metric unit used to measure length

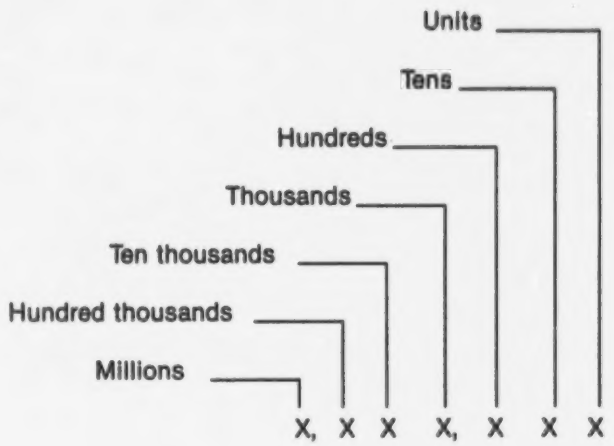
Liter — Metric unit used to measure capacity

Gram — Metric unit used to measure mass or weight

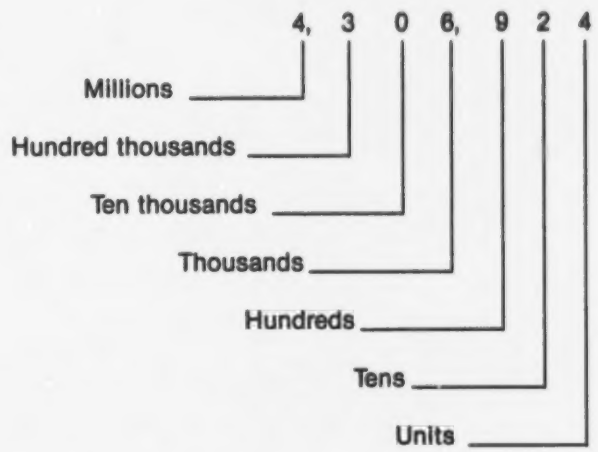
OBJECTIVE 2

Determine the place values of a whole number

NOTE: The position of a digit in a number shows how much that digit is worth. These positions—as shown below—are called *place values*.



EXAMPLE: The example number below is read four million, three hundred six thousand, nine hundred, twenty-four.



OBJECTIVE 7 | **Distinguish among types of fractions**

Proper fraction — Top number of fraction (numerator) is smaller than bottom number of fraction (denominator)

EXAMPLE: $\frac{7}{8}$

Improper fraction — Top number of fraction (numerator) is equal to or larger than bottom number of fraction (denominator)

EXAMPLES: $\frac{9}{8}$, $\frac{16}{16}$

Mixed number — Contains a whole number and a proper fraction

EXAMPLES: $9\frac{1}{2}$, $1\frac{7}{8}$, $4\frac{1}{4}$

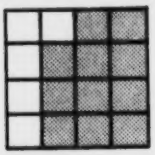
One step more . . .

This figure is divided into eight equal parts:

Five of the eight parts are shaded. $\frac{5}{8}$ of the figure is shaded. We call $\frac{5}{8}$ a fraction. A fraction has a numerator and a denominator.

$\frac{5}{8}$ — Numerator
$\frac{5}{8}$ — Denominator

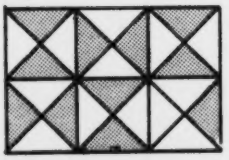
►Tell what part of each figure is shaded.

1. 

4.

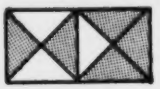
7.

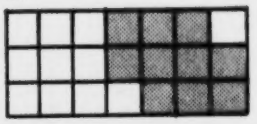
2.

5. 

8.

3.

6. 

9. 

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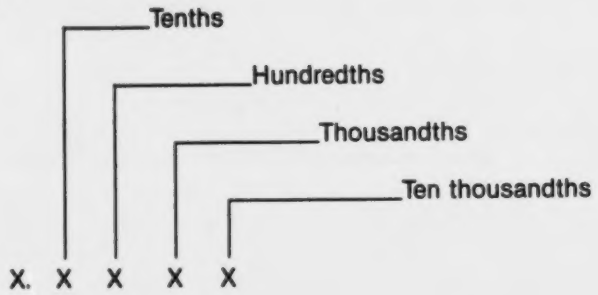
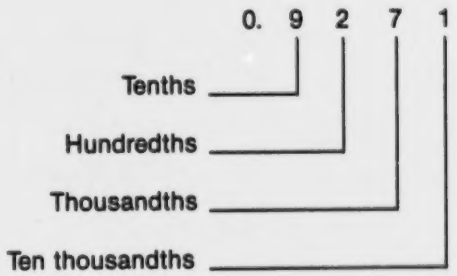
OBJECTIVE 12

Determine the place values of a decimal number

NOTE: As with whole numbers, the place values of a decimal number show how much each digit is worth. Those digits to the right of the decimal have decimal place values, while those digits to the left of the decimal will have whole-number place values.



EXAMPLE: The example number below is read as nine thousand two hundred and seventy-one ten thousandths.



OBJECTIVE 19

Recall the values of prefixes associated with metric measurement

NOTE: The basic units of measurement in the metric system are the meter (length), liter (capacity), and gram (mass or weight). Other units are named by adding the following prefixes to *meter*, *liter*, or *gram*. Since all measurement units in the metric system are powers of 10, metric prefixes make measurements easily understood. A millimeter, for instance, is one thousandth of a meter.

Table 1: Prefixes associated with metric measurement

Prefix	Value
kilo (k)	one thousand (1000)
hecto (h)	one hundred (100)
deka (da)	ten (10)
deci (d)	one tenth ($^1/_{10}$)
centi (c)	one hundredth ($^1/_{100}$)
milli (m)	one thousandth ($^1/_{1000}$)

More About Metrics

The basic unit of length in the metric system is the meter. The distance from the floor to the door handle on an automobile is about 1 meter. Some lengths are too short or too long to measure in meters. Centimeters (cm), millimeters (mm), and kilometers (km) are used to measure these lengths. A kilometer (1000 meters) equals 3280.8 feet or about $^5/_8$ of a mile. A centimeter is about the width of a large paper clip. A millimeter is about the thickness of the wire used to make the paper clip. In the drawing of the metric rule below, each of the numbered spaces is 1 centimeter in length and each of the small spaces is 1 millimeter in length.

Both liquid and dry measurements are given in liters. Smaller amounts are measured in milliliters (mL). Very large amounts are measured in kiloliters (kL). Centiliters (cL) are very seldom used. A 1-pound oil can holds about 1 liter of oil. In the automotive trade, liters are used to measure cooling-system, crankcase, transmission, fuel-tank, and power-steering fluid capacities. A 13-gallon fuel tank, for instance, holds 49.2 liters of fuel. A kiloliter is equal to 1000 liters; thus kiloliters are used to measure very large amounts. The capacity of a tank truck might be measured in kiloliters.

Milligrams (mg), grams (g), kilograms (kg) are used to measure weight. These metric measurements are not frequently encountered in the automotive trade. However, Newton-meters (N-m) are used in the automotive trade in place of inch-pounds and foot-pounds when measuring force such as torque. One Newton-meter equals 0.112 inch-pounds.

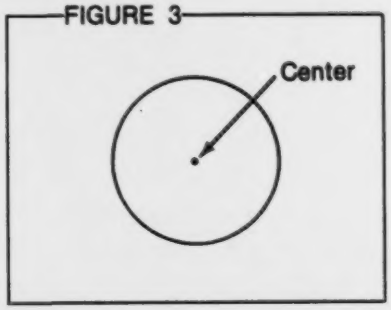
OBJECTIVE 21

Recognize definitions of terms associated with circles

Circle — Closed curved line whose points are all equally distant from the center (Figure 3)

EXAMPLE:

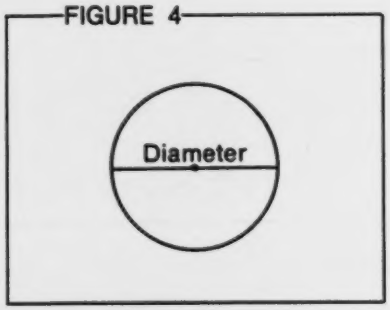
FIGURE 3



Diameter — Length of a line segment through center of circle with its ends on circle; divides circle into two equal parts (halves) (Figure 4)

EXAMPLE:

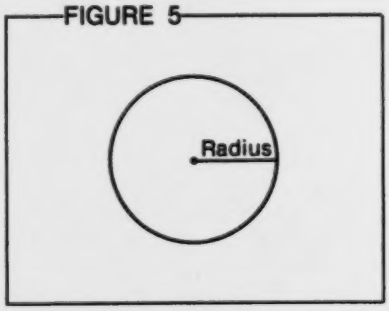
FIGURE 4



Radius — Length of a line segment from center of circle to a point on circle (Figure 5)

EXAMPLE:

FIGURE 5



OBJECTIVE 21

NOTE: The lengths of two radii equal the length of the diameter. See Figure 6.

EXAMPLE:

FIGURE 6

Circumference — Distance around outside of circle (Figure 7)

NOTE: The circumference of a circle is about 3.14 times as long as its diameter.

EXAMPLE:

FIGURE 7

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Degree — $^1/_{360}$ of the circle's circumference

NOTE: A circle is divided into 360 equal parts, or degrees. An angle of 1 degree is formed by drawing two lines from the center of the circle to two consecutive points that cut $^1/_{360}$ of the circumference. See Figure 8.

EXAMPLE:

FIGURE 8

OBJECTIVE 21

Minute — 1/60 of a degree

NOTE: Each degree is divided into 60 equal parts, or minutes. Degrees are designated by placing a small circle to the right and slightly above the degree number. Thus 4 degrees is written 4°. Minutes are indicated by placing a single short slash to the right and slightly above the minute number. Thus 4 minutes is written 4′.

Second — 1/60 of a minute

NOTE: Seconds are indicated by placing two short slashes to the right and slightly above the second number. Thus 4 seconds is written 4″.

SUPPLEMENT 1

Multiplication Table

This supplement is designed to help you master multiplying any two numbers from zero to twelve in your head without using pencil and paper. It is not pratical to add, for instance, seven 9s in a column when you can memorize the multiplication table and perform calculations more quickly in your head.

To use the table below, locate the row and column numbers that you want to multiply, and then move down and over to the number where the row and column numbers meet. This number will be the answer (product) of multiplying the two numbers. Memorize *all* of the products of any two numbers multiplied together.

EXAMPLE: 2 x 5 = 10

ROW

COLUMN	1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24	

ROW

COLUMN	1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12	
2	4	6	8	10	12	14	16	18	20	22	24	
3	6	9	12	15	18	21	24	27	30	33	36	
4	8	12	16	20	24	28	32	36	40	44	48	
5	10	15	20	25	30	35	40	45	50	55	60	
6	12	18	24	30	36	42	48	54	60	66	72	
7	14	21	28	35	42	49	56	63	70	77	84	
8	16	24	32	40	48	56	64	72	80	88	96	
9	18	27	36	45	54	63	72	81	90	99	108	
10	20	30	40	50	60	70	80	90	100	110	120	
11	22	33	44	55	66	77	88	99	110	121	132	
12	24	36	48	60	72	84	96	108	120	132	144	

SUPPLEMENT 2

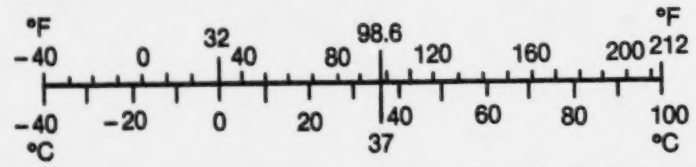
Metric and Customary Decimal Equivalents for Fractional Parts of an Inch

Fraction	Decimal equivalent		Fraction	Decimal equivalent	
	Customary (in.)	Metric (mm)		Customary (in.)	Metric (mm)
1/64	.015625	0.3969	33/64	.515625	13.0969
1/32	.03125	0.7938	17/32	.53125	13.4938
3/64	.046875	1.1906	35/64	.546875	13.8906
1/16	.0625	1.5875	9/16	.5625	14.2875
5/64	.078125	1.9844	37/64	.578125	14.6844
3/32	.09375	2.3813	19/32	.59375	15.0813
7/64	.109375	2.7781	39/64	.609375	15.4781
1/8	.1250	3.1750	5/8	.6250	15.8750
9/64	.140625	3.5719	41/64	.640625	16.2719
5/32	.15625	3.9688	21/32	.65625	16.6688
11/64	.171875	4.3656	43/64	.671875	17.0656
3/16	.1875	4.7625	11/16	.6875	17.4625
13/64	.203125	5.1594	45/64	.703125	17.8594
7/32	.21875	5.5563	23/32	.71875	18.2563
15/64	.234375	5.9531	47/64	.734375	18.6531
1/4	.250	6.3500	3/4	.750	19.0500
17/64	.265625	6.7469	49/64	.765625	19.4469
9/32	.28125	7.1438	25/32	.78125	19.8438
19/64	.296875	7.5406	51/64	.796875	20.2406
5/16	.3125	7.9375	13/16	.8125	20.6375
21/64	.328125	8.3384	53/64	.828125	21.0344
11/32	.34375	8.7313	27/32	.84375	21.4313
23/64	.359375	9.1281	55/64	.859375	21.8281
3/8	.3750	9.5250	7/8	.8750	22.2250
25/64	.390625	9.9219	57/64	.890625	22.6219
13/32	.40625	10.3188	29/32	.90625	23.0188
27/64	.421875	10.7156	59/64	.921875	23.4156
7/16	.4375	11.1125	15/16	.9375	23.8125
29/64	.453125	11.5094	61/64	.953125	24.2094
15/32	.46875	11.9063	31/32	.96875	24.6063
31/64	.484375	12.3031	63/64	.984375	25.0031
1/2	.500	12.7000	1	1.000	25.4000

SUPPLEMENT 3

Metric/Customary Conversion Table

Multiply	by	to get equivalent number of:
LENGTH		
Inch	25.4	millimeters (mm)
Foot	0.304	meters (m)
Yard	0.914	meters
Mile	1.609	kilometers (km)
AREA		
Inch^2	645.2	millimeters^2 (mm^2)
	6.45	centimeters^2 (cm^2)
Foot^2	0.092	meters^2 (m^2)
Yard^2	0.836	meters^2
VOLUME		
Inch^3	16 387.	mm^3
	16.387	cm^3
	0.016	liters (l)
Quart	0.946	liters
Gallon	3.785	liters
Yard^3	0.764	meters^3 (m^3)
MASS		
Pound	0.453	kilograms (kg)
Ton	907.18	kilograms (kg)
Ton	0.907	tonne (t)
FORCE		
Kilogram	9.807	newtons (N)
Ounce	0.278	newtons
Pound	4.448	newtons
TEMPERATURE		
Degree Fahrenheit	(°F-32) ÷ 1.8	degree Celsius (C)



Metric/customary conversion table (continued)

Multiply	by	to get equivalent number of:
	ACCELERATION	
Foot/sec^2	0.304	meter/sec^2 (m/s^2)
Inch/sec^2	0.025	meter/sec^2
	TORQUE	
Pound-inch	0.112	newton-meters (N-m)
Pound-foot	1.355	newton-meters
	POWER	
Horsepower	0.746	kilowatts (kW)
	PRESSURE OR STRESS	
Inches of mercury	3.377	kilopascals (kPa)
Pounds/sq in.	6.895	kilopascals
	ENERGY OR WORK	
BTU	1 055.	joules (J)
Foot-pound	1.355	joules
Kilowatt-hour	3 600 000. or 3.6×10^6	joules (J = one W's)
	LIGHT	
Foot candle	10.764	lumens/meter^2 (lm/m^2)
	FUEL PERFORMANCE	
Miles/gal	0.425	kilometers/liter (km/l)
Gal/mile	2.352	liters/kilometer (l/km)
	VELOCITY	
Miles/hour	1.609	kilometer/hr (km/h)

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ASSIGNMENT SHEET 1

APPLY RELATED MATH AND MEASURING

OBJECTIVE 3

Add whole numbers

Name _____ Score _____

INTRODUCTION

Like most people, you probably use addition every day. For example, today you probably added coins together to pay for a soft drink and snacks. Every time you add, you use basic addition facts. The following exercises will form part of your automotive math background and serve as a basis for completing other exercises and problems.

Adding whole numbers

1. Set up problem by writing units under units, tens under tens, and so on

   EXAMPLE: Add the whole numbers 1632, 17, and 550.

   ```
    1632
      17
   + 550
   ```

2. Add each column separately, beginning at top of units column

   EXAMPLE:

   ```
    1632        1632
      17          17
   + 550       + 550
       9          99
   ```

3. If the sum of any column is two or more digits, write the units digit in your answer and carry the remaining digit(s) to the top of the next column to the left

   EXAMPLE:

   ```
                          1      — Carry
    1632        1632      1632   remaining
      17          17        17   digit.
   + 550       + 550     + 550
     199         199       199
   ```

   Write units digit. —

4. Add any carried digit(s) above the column with that column

   EXAMPLE:

   ```
     1      — Carried digit
    1632
      17
   + 550
    2199
   ```

PART 1

Solve each of the following addition problems.

1.	2 + 9	2.	8 + 8	3.	7 + 6	4.	15 + 8
5.	81 + 27	6.	7 38 + 43	7.	55 88 + 99	8.	341 428 + 769
9.	472 564 + 881	10.	9876 5432 + 1122				

PART 2

Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. The automotive specialist has 12 replacement brake drums. He has ordered and received 8 additional drums. How many total brake drums does he have?

   Total brake drums = _____

2. An automobile has a 34-candlepower bulb, a 26-candlepower bulb, a 9-candlepower bulb, and a 15-candlepower bulb. Find the total candlepower.

   Total candlepower = _____

3. An automotive specialist ordered the following number of bolts on different dates: 256, 62, 575, and 242. How many bolts should she be billed for?

   Number of bolts = _____

4. If an automotive specialist paid $480 for a transmission, $13 for parts, $81 for a clutch, and $35 for a slave cylinder, what was the total cost of these parts?

   Total cost of parts = _____

5. On a major engine overhaul, Bill worked 28 hours, Tom worked 16 hours, and Mary worked 42 hours. What are the total hours worked on this job?

   Total hours worked = _____

6. In a toolbox are 23 socket wrenches, 14 open-end wrenches, 11 tubing wrenches, and 5 torque wrenches. How many wrenches are in the toolbox?

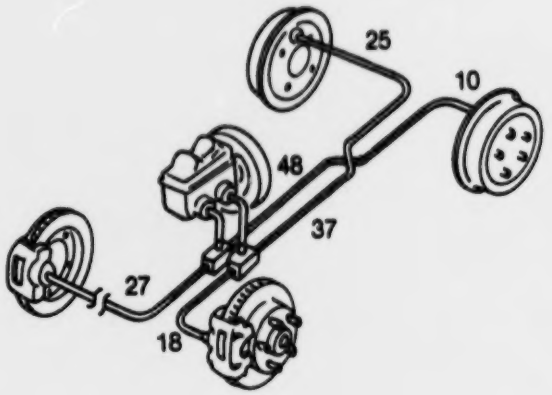
   Number of wrenches in toolbox = _____

7. There are 13 large boxes in the toolroom, 7 medium boxes, and 11 small boxes. How many boxes are in the toolroom?

   Number of boxes = _____

8. A brakes specialist installed the new brake line illustrated below. What was the total length of brake line used? (The end-to-end measurement of each segment of line is given in inches.)

Total length of brake line in inches = _____



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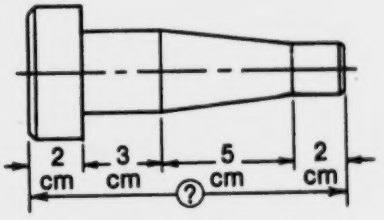
9. What is the overall length of the spindle component illustrated below?

Overall length in centimeters = _____



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10. Six vehicles are being worked on by automotive specialists. The number of parts that must be serviced is 65, 75, 69, 81, 57, and 76. What is the total number of parts that must be serviced?

Total number of parts = _____

ASSIGNMENT SHEET 2	APPLY RELATED MATH AND MEASURING

OBJECTIVE 4 — **Subtract whole numbers**

Name _____ Score _____

INTRODUCTION

Addition is the first basic operation of mathematics. Subtraction, the opposite of addition, is the process of finding the difference between two numbers. It is the second basic math operation.

Subtracting whole numbers

1. Set up problem by writing units under units, tens under tens, and so on

   NOTE: The top number in the problem (original number) is almost always larger than the bottom number (subtracted number).

   EXAMPLE: Subtract 91 from 123.

   ```
     123   Original number
   - 91    Subtracted number
   ```

2. Subtract each column separately, beginning at bottom of units column

   EXAMPLE:
   ```
     123
   - 91 ↓
     2
   ```

3. If a digit in the subtracted number is larger than the digit above it, "borrow" 1 from the top digit in the next column to the left, decreasing that digit by one and increasing the digit being subtracted from by ten

   EXAMPLE:
   ```
     0        012
    ~~1~~23   ~~1~~ ~~2~~ 3
   - 91      - 9  1
     2         3  2
   ```

4. If there is nothing to borrow in the next left column (column contains a zero), first borrow for that column from its next left column

EXAMPLE:

906	8 10	8 9 10	8 9 10 16
− 318	− 3 1 8	− 3 1 8	− 3 1 8
			5 8 8

5. Check your subtraction by adding your answer (difference) to the subtracted number

EXAMPLE:

Problem		Check	
271	Original number	271	Original number
− 164	Subtracted number	− 164	Subtracted number
107	Answer (difference)	+ 107	Answer (difference)
		271	Check answer

NOTE: If you solved the problem correctly, your check answer should be the same as the original number.

PART 1

Solve each of the following subtraction problems. Check your answers by adding the difference to the subtracted number.

1.	9 − 5	2.	15 − 8	3.	75 − 22	4.	453 − 47
5.	742 − 318	6.	981 − 698	7.	1420 − 245	8.	3459 − 1649
9.	55,722 − 4,272	10.	98,679 − 8,957				

318

PART 2

Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks. Check your answers by adding the difference to the subtracted number.

1. If a shop needs 172 shop towels for a job and it has 46, how many more shop towels would the shop need?

   Number of shop towels needed = _____

2. If there are 18 spark plugs on inventory and you use 6 of them, how many are left?

   Number of spark plugs left = _____

3. Sue worked 34 hours on a major repair job, and Henry worked 56 hours on a similar repair job. How many more hours did Henry work than Sue?

   Difference in hours worked = _____

4. In the first year of operation, an automotive shop handled 1219 jobs. During the second year, the jobs increased to 2167. How many more jobs did the shop do the second year?

   Difference in jobs = _____

5. To repair the brakes on one late-model vehicle takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

   Difference in minutes worked = _____

6. Mr. Smith, the instructor, has 240 cotter pins in stock. If 98 are needed during the first semester course, how many are left for the second semester?

   Number of cotter pins left = _____

7. If the average curb weight of an automobile is 2100 pounds, and the car you are servicing has a curb weight of 2310 pounds, how much above average is the curb weight of the car you are servicing?

   Pounds above average curb weight = _____

8. You can work only 13 hours this week on an engine overhaul. The following week you can work 6 hours. How much additional time will it take the third week if the job will take 27 total hours?

   Additional hours required = _____

9. The transportation pool uses 250 liters of oil per semester. There are only 137 liters of oil in the storage room. How many more liters will be needed for the semester?

Liters needed = _____

10. Determine the number of kilometers traveled for each of five weeks from the odometer readings below.

Week	1	2	3	4	5
Reading (start)	32,119	32,899	33,988	35,976	37,065
Reading (end)	32,899	33,988	35,976	37,065	39,001

Week 1 _____ km Week 4 _____ km

Week 2 _____ km Week 5 _____ km

Week 3 _____ km

ASSIGNMENT SHEET 3

APPLY RELATED MATH AND MEASURING

OBJECTIVE 5

Multiply whole numbers

Name _____ Score _____

INTRODUCTION

Multiplication is the third basic operation in mathematics. It is a shortcut method of adding. For example, if you correctly add twelve 12s, the result will be 144, the same as 12 multiplied by 12. Some multiplication problems involve carrying. You may write down the carried digits, or simply remember them. Use the method that works best for you. Follow the steps below for multiplying whole numbers.

Multiplying whole numbers

1. Set up problem by writing the larger number (original number) above the smaller number (multiplier), writing units under units, tens under tens, and so on

   NOTE: You will get the correct answer (product) no matter which number is placed above the other, but the faster method places the larger above the smaller.

   EXAMPLE: Multiply the numbers 53 and 4.

   ```
     53   Original number
   x  4   Multiplier
   ```

2. If the multiplier contains only one digit, multiply each digit in the original number by it, working from right to left

   a. Multiply units digit in original number by multiplier

   b. Write answer units digit, and insert necessary carry digit above next left column in original number as required

   EXAMPLE:

   ```
     1   — Carried digit
    53
   x 4
   ---
    2
   ```

   c. Multiply tens digit by multiplier and add carried digit as required

   EXAMPLE:

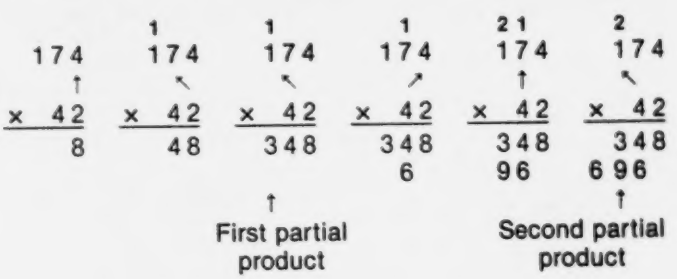
   ```
     1
    53
   x 4
   ---
   212
   ```

3. If the multiplier contains more than one digit, find partial products

   a. Multiply each digit in original number by each digit in multiplier, moving from right to left

   b. Align partial products so that right-hand digit of each is directly under its corresponding digit in the multiplier

      EXAMPLE: Multiply the numbers 174 and 42.



   c. Add the partial products

      EXAMPLE:

```
  174
× 42
  348
+ 696
 7308   — Answer (product)
```

PART 1

Solve the following multiplication problems.

1.	6 × 7	2.	9 × 8	3.	54 × 6	4.	721 × 4
5.	1682 × 5	6.	78 × 26	7.	453 × 47	8.	314 × 527
9.	2143 × 235	10.	4123 × 1324				

PART 2

Solve the following problems. Show your work in the spaces provided. Write your answers on the blanks.

1. There are 4 spark plugs in a package. How many plugs are in 8 packages?

   Number of spark plugs = _____

2. There are 24 cans of oil in a case. How many cans of oil are in 4 cases?

   Number of oil cans = _____

3. There are 500 bolts in a box. How many are in 6 boxes?

   Number of bolts = _____

4. If it takes 4 new tires per car, how many tires will be needed for 6 cars?

   Tires needed = _____

5. There are 16 student automotive specialists working on repair jobs. If each student works 8 hours, what are the total hours spent?

   Total hours spent = _____

6. If a can of lubricating grease costs $6 per pound, how much will 58 pounds of grease cost?

   Cost of lubricating grease = _____

7. It takes 35 minutes to change the oil and replace the filter on one car. How much time does it take to do the same job on 9 cars?

   Total minutes required = _____

8. How many cars can be washed in an automatic car wash in 9 hours if 15 can be washed in 1 hour?

   Total cars washed = _____

9. Figure the amount of time worked in 4 weeks by 12 automotive specialists who work 30 hours each week.

   Hours worked = _____

10. A truck travels 42 kilometers an hour for 6 hours daily for 19 days. Another truck travels 37 kilometers an hour for 6 hours daily for 23 days. A third truck travels 39 kilometers an hour for 6 hours daily for 22 days. What is the total kilometers of the three trucks?

    Total kilometers = _____

ASSIGNMENT SHEET 4	APPLY RELATED MATH AND MEASURING

OBJECTIVE 6 **Divide whole numbers**

Name _____ Score _____

INTRODUCTION

Automotive specialists use division in many aspects of their work. Calculating horsepower, figuring Ohm's law, and determining piston displacement to name a few. Division is the fourth and last basic operation in mathematics. Multiplication puts together; division takes apart. Division is the reverse of multiplication. Division answers are checked by multiplying the divisor by the answer and adding the remainder. Follow the steps below for dividing whole numbers.

Dividing whole numbers

1. Set up problem by writing original number (number to be divided) inside a division frame, and by writing divisor (number you are dividing by) outside frame

   EXAMPLE: How many times will 34 go into 3347?

   Divisor $34\overline{)3347}$ Original number

2. Determine how many times the divisor will go into the first digit of the original number; if it will not, write a zero in the answer space directly above the first digit, then determine how many times the divisor will go into the first two numbers of the original number

   NOTE: Continue trying to divide the original number by the divisor until a set of digits can be divided. Remember to write a zero each time the set of digits cannot be divided.

   EXAMPLE:

   $\begin{array}{r} 0 \\ 34\overline{)3347} \end{array}$ 34 goes into 3 zero times.

   $\begin{array}{r} 00 \\ 34\overline{)3347} \end{array}$ 34 goes into 33 zero times.

   $\begin{array}{r} 009 \\ 34\overline{)3347} \end{array}$ 34 goes into 334 nine times.

3. Multiply the divisor by the answer (digit above frame); write this answer under the digits that divisor went into and subtract

EXAMPLE:
```
  34
 x 9
 306
```
Multiply divisor (34) by answer (9).

```
   009
34 )3347
  -306
    28
```
Write answer under 334, the digits divisor went into, and subtract.

4. Bring down next unused digit from original number, and place it to the right of the subtracted difference (remainder)—even if the remainder is zero

EXAMPLE:
```
   009
34 )3347
  -306↓
    287
```

5. Determine how many times the divisor will go into this new number; write your answer directly above the digit that was brought down

EXAMPLE:
```
   0098
34 )3347
  -306
    287
```

6. Multiply the divisor by the last digit you wrote in answer; write this product under the digits that divisor went into, and subtract

EXAMPLE:
```
  34
 x 8
 272
```
Multiply divisor (34) by last digit of answer (8).

```
   0098
34 )3347
  -306
    287
  -272
     15
```
Write product under 287, the digits that divisor went into, and subtract.

7. Continue this process until all numbers in original number are used; write any remaining subtracted difference as a remainder

EXAMPLE:

```
  0098
34)3347
  306
   287
   272
    15   Remainder
```

8. Check your answer by multiplying your answer times the divisor and adding the remainder to this number; your check answer should be the same as the original number

EXAMPLE:

```
   98   Answer
 ×34    Divisor
  392
 294
 3332
+ 15    Remainder
 3347    Check answer (same as original number)
```

PART 1

Solve the following division problems. Check your answers by multiplying the divisor by the original number.

1. $2\overline{)8}$
2. $6\overline{)48}$
3. $9\overline{)819}$
4. $4\overline{)1248}$
5. $13\overline{)39}$
6. $66\overline{)198}$
7. $84\overline{)5208}$
8. $124\overline{)2604}$
9. $464\overline{)928}$
10. $746\overline{)2238}$

PART 2

Solve the following problems. Show your work in the spaces provided. Write your answer on the blanks.

1. If a can of lubricant holds 5 pounds, how many cans can be filled from a 55-pound drum?

   Number of cans = _____

2. Sam received $418 for an engine overhaul job. He worked 19 hours on the job. How much did he make per hour?

   Amount earned per hour = _____

3. How many 4-liter oil changes can be made using cases containing 416 liters of oil?

   Number of oil changes = _____

4. If Jill can repair brakes on 4 automobiles a day, how many days will it take her to repair the brakes on 92 automobiles?

   Number of days = _____

5. A new engine analyzer machine costs $13,104. How much will the school's monthly payments be if the analyzer is financed over a 14-month period?

   Monthly payments = _____

6. A car salesperson has 3828 sales cards. He gives away 116 each day. How many days' supply does he have?

   Number of days = _____

ASSIGNMENT SHEET 5

APPLY RELATED MATH AND MEASURING

OBJECTIVE 8

Reduce fractions to lowest terms

Name _____ Score _____

INTRODUCTION

Fractions are "reduced" to their lowest terms so that they are more readily understood or recognized. For example, 1/2 is more easily recognized than 16/32.

Reducing proper fractions

To reduce proper fractions to their lowest terms, divide the numerator (top number) and denominator (bottom number) by the largest whole number that will go into each evenly.

EXAMPLE: Reduce 4/16 to its lowest terms.

$$4/16 = \frac{4 \div 4}{16 \div 4} = \frac{1}{4}$$

NOTE: The fraction 1/4 is reduced to its lowest terms because the numerator (1) and the denominator (4) cannot be divided evenly by the same number.

Reducing improper fractions

1. Divide the numerator by the denominator

   EXAMPLE: Reduce 20/16 to its lowest terms.

   $20 \div 16 = 1\ 4/16$

2. Reduce the resulting fraction to its lowest terms as for proper fractions

   EXAMPLE: $4/16 = \frac{4 \div 4}{16 \div 4} = \frac{1}{4}$

3. Add the reduced fraction to its whole number

   EXAMPLE: $1 + 1/4 = 1\ 1/4$ Answer

Reduce the following fractions to their lowest terms. Show your work in the space below the problems, and then write your answers on the blanks.

1. $^{4}/_{8}$ = _____
2. $^{8}/_{16}$ = _____
3. $^{2}/_{2}$ = _____
4. $^{4}/_{16}$ = _____
5. $^{12}/_{36}$ = _____
6. $^{9}/_{24}$ = _____
7. $^{16}/_{32}$ = _____
8. $^{12}/_{9}$ = _____
9. $^{5}/_{2}$ = _____
10. $^{36}/_{8}$ = _____

ASSIGNMENT SHEET 6

APPLY RELATED MATH AND MEASURING

OBJECTIVE 9

Convert mixed numbers to improper fractions and improper fractions to mixed numbers

Name _____ Score _____

INTRODUCTION

A fraction such as 3/4 is called a *proper fraction* because its numerator (top number) is smaller than its denominator (bottom number). Some examples of proper fractions are 1/2, 3/4, 7/8.

When the numerator of a fraction is the same or larger than the denominator, the fraction is called an *improper fraction*. Some examples of improper fractions are 4/4, 5/3, 9/4, and 10/8.

Numbers such as 2 1/2, 5 3/4, and 6 2/5 are called *mixed numbers*. They are made up of a whole number and a proper fraction.

Follow the steps below for converting mixed numbers to improper fractions and improper fractions to mixed numbers.

Converting mixed numbers to improper fractions

1. Multiply the whole number by the denominator of the fraction

   EXAMPLE: Convert 4 3/8 to an improper fraction.

   $8 \times 4 = 32$

2. Add your answer to the numerator

   EXAMPLE: $32 + 3 = 35$

3. Place this sum over the original denominator

   EXAMPLE: $\frac{35}{8}$ Improper fraction

Converting improper fractions to mixed numbers

1. Divide the numerator by the denominator

   EXAMPLE: Convert $^{18}/_{15}$ to a mixed number.

$$15\overline{)18}\quad 01$$
$$\underline{15}$$
$$3 \text{ Remainder}$$

2. Place the remainder over the denominator

   EXAMPLE: $\frac{3}{15}$ — Remainder / Denominator

3. Reduce this fraction if necessary

   EXAMPLE: $\frac{3}{15} = \frac{3 \div 3}{15 \div 3} = \frac{1}{5}$

4. Add the reduced fraction to the whole number obtained by dividing the numerator by the denominator

   EXAMPLE: $1 + {}^{1}/_{5} = 1\ {}^{1}/_{5}$ Mixed number

PART 1

Distinguish among the following fractions by writing a "P" on the blank before a proper fraction, an "I" before an improper fraction, and an "M" on the blank before a mixed number.

_____ 1. $^{1}/_{2}$

_____ 2. $3\ {}^{7}/_{8}$

_____ 3. $^{16}/_{2}$

_____ 4. $3\ {}^{1}/_{8}$

_____ 5. $^{1}/_{4}$

_____ 6. $^{1}/_{1}$

_____ 7. $^{7}/_{2}$

_____ 8. $8\ {}^{1}/_{2}$

_____ 9. $^{4}/_{4}$

_____ 10. $9\ {}^{3}/_{16}$

_____ 11. $5\ {}^{1}/_{2}$

_____ 12. $^{9}/_{8}$

_____ 13. $^{9}/_{4}$

_____ 14. $^{1}/_{8}$

_____ 15. $16\ {}^{3}/_{4}$

PART 2

Convert the following mixed numbers to improper fractions. Show your work in the space provided below the problems. Reduce to lowest terms when possible. Write your answers on the blanks beside the problems.

1. $3\frac{1}{4}$ = _____
2. $4\frac{1}{2}$ = _____
3. $7\frac{3}{4}$ = _____
4. $8\frac{1}{2}$ = _____
5. $6\frac{1}{8}$ = _____
6. $5\frac{2}{4}$ = _____
7. $4\frac{1}{4}$ = _____
8. $9\frac{1}{2}$ = _____
9. $9\frac{1}{4}$ = _____
10. $16\frac{1}{2}$ = _____

PART 3

Convert the following improper fractions to mixed numbers. Show your work in the space provided below the problems. Reduce to lowest terms when possible. Write your answers on the blanks beside the problems.

1. $\frac{7}{4}$ = _____
2. $\frac{9}{2}$ = _____
3. $\frac{6}{4}$ = _____
4. $\frac{15}{8}$ = _____
5. $\frac{19}{16}$ = _____
6. $\frac{11}{8}$ = _____
7. $\frac{76}{32}$ = _____
8. $\frac{5}{2}$ = _____
9. $\frac{15}{4}$ = _____
10. $\frac{33}{16}$ = _____

ASSIGNMENT SHEET 7

APPLY RELATED MATH AND MEASURING

OBJECTIVE 10

Add fractions

Name _____ Score _____

INTRODUCTION

Automotive specialists are often required to take measurements and perform hand and machine operations. These procedures require the computation of missing or needed dimensions. Whole numbers alone are not sufficient to obtain specific dimensions. Therefore, the specialist must be able to add fractional parts. The steps for adding fractions are outlined below.

Adding like fractions

EXAMPLE: Add $^3/_4$ and $^3/_4$.

1. Add the numerators

   EXAMPLE: 3 + 3 = 6

2. Place answer over common denominator and reduce to lowest terms if necessary

   EXAMPLE: $^6/_4 = 1\ ^2/_4 = 1\ ^1/_2$ Answer

Adding unlike fractions

EXAMPLE: Add $^1/_4 + {}^7/_8$.

1. Change to equivalent fractions with lowest common denominator

   EXAMPLE: $^7/_8$ remains the same, as 8 is lowest common denominator.

   $^1/_4$ is multiplied by $^2/_2$, or $^1/_4 \times {}^2/_2 = {}^2/_8$.

2. Add the new numerators

   EXAMPLE: $\frac{7 + 2}{8} = {}^9/_8$

3. Change improper fraction to mixed number and reduce to lowest terms if necessary

   EXAMPLE: $^9/_8 = 9 \div 8 = 1\ ^1/_8$ Answer

Adding mixed numbers

EXAMPLE: Add $3\ 5/8 + 7\ 5/8$.

1. Add numerators

   EXAMPLE: $\frac{5 + 5}{8} = 10/8$

2. Change improper fraction to mixed number and reduce to lowest terms if necessary

   EXAMPLE: $10/8 = 10 \div 8 = 1\ 2/8 = 1\ 1/4$

3. Add whole numbers and fractions

   EXAMPLE: $3 + 7 + 1 + 1/4 = 11\ 1/4$ Answer

PART 1

Add the following fractions. Show your work in the space provided below the problems. Reduce to lowest terms if necessary. Write your answers on the blanks beside the problems.

1. $7/16 + 5/16 =$ _____
2. $5/8 + 7/8 =$ _____
3. $1/4 + 2/8 =$ _____
4. $4/16 + 3/4 =$ _____
5. $9/16 + 5/8 =$ _____
6. $5/8 + 5/32 =$ _____
7. $3/4 + 5/32 =$ _____
8. $7/8 + 6/16 =$ _____
9. $9/16 + 3/4 =$ _____
10. $4/4 + 25/32 =$ _____

PART 2

Solve the following problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. Add the lengths of two wires that are 6 1/2 inches and 8 1/4 inches.

   Total length in inches = _____

2. Tom worked 4 1/2 hours before lunch and 3 1/4 hours after lunch. How many hours did Tom work?

   Total hours worked = _____

3. Add the lengths of three extension tools that are 2 1/8 inches, 3 1/4 inches, and 1 13/16 inches.

   Total length in inches = _____

4. Three pieces of heater hose have lengths of 6 5/8 inches, 6 3/4 inches, and 6 1/4 inches. What is the total length of the three pieces of hose?

   Total length in inches = _____

5. In learning to read an English rule, Jim located 4 7/8 inches on the rule, Jill read 3 15/16 inches, and Greg located 4 1/4 inches. How many total inches were located?

   Total inches = _____

6. Add three brake-line segments 17 15/16 inches, 16 3/4 inches, and 25 3/8 inches.

   Combined line segments in inches = _____

7. Three dimensions are 1 11/16 inches, 2 3/8 inches, and 2 3/4 inches. What is the combined dimension?

   Combined dimension in inches = _____

8. A container of oil has 2 1/2 liters in it. Sally adds 1 3/4 liters. How many liters are now in the container?

   Total liters of oil = _____

9. A specialist worked 5 7/8 hours, 3 3/4 hours, and 7 7/16 hours on a job. How many total hours did the specialist work?

   Total hours = _____

ASSIGNMENT SHEET 8	APPLY RELATED MATH AND MEASURING

OBJECTIVE 11

Subtract fractions

Name _____ Score _____

INTRODUCTION

Just as the automotive specialist needs to know how to add fractions to compute day-to-day measurements and amounts, the specialist must also know how to subtract fractions.

Follow the steps outlined below for subtracting various types of fractions.

Subtracting like fractions

EXAMPLE: Subtract $^{1}/_{16}$ from $^{7}/_{16}$.

1. Subtract smaller numerator from larger numerator

   EXAMPLE: 7 – 1 = 6

2. Place answer over common denominator

   EXAMPLE: $^{6}/_{16}$

3. Reduce to lowest terms if required

   EXAMPLE: $^{6}/_{16} = {}^{3}/_{8}$ Answer

Subtracting unlike fractions

EXAMPLE: Subtract $^{1}/_{2}$ from $^{3}/_{4}$.

1. Change to like fractions

   EXAMPLE: $^{3}/_{4}$ remains the same because 4 is the common denominator.

   $^{1}/_{2}$ is multiplied by $^{2}/_{2}$, or $^{1}/_{2} \times {}^{2}/_{2} = {}^{2}/_{4}$.

2. Subtract as for like fractions and reduce to lowest terms if required

   EXAMPLE: $^{3}/_{4} - {}^{2}/_{4} = {}^{1}/_{4}$ Answer

Subtracting mixed numbers

EXAMPLE: Subtract $3\ 1/2$ from $5\ 1/8$.

1. Change mixed numbers to like fractions

   EXAMPLE: $3\ 1/2 = 3\ 4/8$

2. Borrow a 1 from the original whole number if needed, and convert the 1 to a like fraction, and add it to the smaller fraction

   NOTE: This step is needed only if the like fraction in the original number is smaller than the like fraction in the subtracted number.

   EXAMPLE: $5\ 1/8 - 3\ 4/8 = (4\ 8/8 + 1/8) - 3\ 4/8 = 4\ 9/8 - 3\ 4/8$

3. Subtract whole number from whole number and like fraction from like fraction, and reduce answer to lowest terms if required

   EXAMPLE: $4\ 9/8 - 3\ 4/8 = 1\ 5/8$ Answer

Subtracting a fraction from a whole number

EXAMPLE: $4 - 3/16$

1. Borrow 1 from whole number

   EXAMPLE: $4 - 1 = 3$

2. Change borrowed 1 to like fraction

   EXAMPLE: $1 = 16/16$

3. Subtract as for like fractions and reduce answer to lowest terms if required

   EXAMPLE: $3\ 16/16 - 3/16 = 3\ 13/16$ Answer

PART 1

Subtract the proper fractions given below. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $\frac{3}{4} - \frac{3}{16} =$ _____

2. $\frac{7}{8} - \frac{1}{4} =$ _____

3. $\frac{30}{32} - \frac{3}{4} =$ _____

4. $\frac{25}{32} - \frac{5}{8} =$ _____

5. $\frac{7}{8} - \frac{2}{16} =$ _____

6. $\frac{15}{16} - \frac{3}{8} =$ _____

7. $\frac{1}{2} - \frac{7}{16} =$ _____

8. $\frac{3}{4} - \frac{3}{8} =$ _____

9. $\frac{13}{16} - \frac{9}{32} =$ _____

10. $\frac{7}{8} - \frac{6}{16} =$ _____

PART 2

Subtract the following fractions from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $4 - \frac{3}{4} =$ _____

2. $7 - \frac{15}{16} =$ _____

3. 32 – $^{13}/_{32}$ = _____

4. 175 – $^{4}/_{5}$ = _____

5. 12 – $^{61}/_{64}$ = _____

PART 3

Subtract the following mixed numbers from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. 2 – 1 $^{1}/_{3}$ = _____

2. 3 – 1 $^{3}/_{8}$ = _____

3. 18 – 9 $^{7}/_{8}$ = _____

4. 3 – 1 $^{21}/_{32}$ = _____

5. $27 - 1\frac{5}{16} =$ _____

9. $4 - 3\frac{1}{3} =$ _____

6. $14 - 6\frac{3}{4} =$ _____

10. $42 - 3\frac{7}{16} =$ _____

7. $5 - (3\frac{5}{32} + 1\frac{9}{32}) =$ _____

8. $8 - (1\frac{1}{4} + 5\frac{5}{8} + \frac{1}{16}) =$ _____

PART 4

Subtract the following mixed numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $1\frac{3}{5} - 1\frac{1}{5} =$ _____

2. $72\frac{6}{16} - 22\frac{7}{16} =$ _____

3. $7\frac{5}{8} - 2\frac{1}{8} =$ _____

4. $18\frac{7}{8} - 9\frac{3}{8} =$ _____

5. $35\frac{5}{8} - 8\frac{1}{2} =$ _____

6. $5\frac{1}{4} - (1\frac{1}{8} + 1\frac{7}{8}) =$ _____

7. $12\frac{1}{2} - (7\frac{1}{4} + 3\frac{1}{8}) =$ _____

8. $4\frac{29}{32} - 1\frac{19}{32} =$ _____

9. $5\frac{15}{32} - 2\frac{31}{32} =$ _____

10. $8\frac{1}{16} - 4\frac{7}{8} =$ _____

PART 5

Solve the following word problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. **Bill had a 7/8-inch wrench. He needed a 3/4-inch wrench. How much difference is there in the size of the wrenches?**

   Difference in inches = _____

2. **Susan worked 5 1/4 hours on a repair and Don worked 4 1/2 hours on the same type of repair. How much faster did Don work than Susan?**

   Difference in hours = _____

3. **A motor base is to be set up 4 1/2 inches from the floor. Two wooden blocks must be used. If one block is 1 5/8 inches thick, how thick must the second block be?**

   Thickness of block in inches = _____

4. **Three pieces of brake line are cut from a piece 35 1/2 inches long. The lengths are 7 1/4 inches, 11 3/8 inches, and 6 1/2 inches. If 3/8 inch of line is wasted in cutting, how much line is left?**

   Length of line left in inches = _____

5. A piece of radiator hose is 32 1/2 inches long. Short pieces of the following lengths are cut from it: 6 1/2 inches, 5 1/4 inches, 8 13/16 inches, and 10 9/16 inches. How much hose is left?

   Amount of hose left in inches = _____

6. A fuel tank has 16 3/10 gallons in it. After a trip that uses 9 3/4 gallons, how many gallons will be left?

   Number of gallons = _____

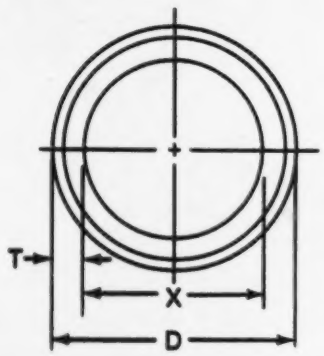
7. An engine crankcase holds 4 1/4 liters of oil. How much oil is left after a trip if the engine uses 1/2 liter?

   Number of liters = _____

8. A bolt is 1/2 inch by 10 inches. If 1 3/8 inches are cut from its length, what will be the final size of the bolt?

   Bolt size in inches = _____

9. Determine the inside diameter of each shim listed below. All dimensions are in inches.



Used with permission of Ford Motor Company.

Shim	Outside diameter (D)	Single-wall thickness (T)	Inside diameter (X)
A	1	1/16	
B	2 1/8	3/16	
C	2 15/32	9/64	
D	3 1/64	15/32	
E	1 9/64	9/32	

ASSIGNMENT SHEET 9

APPLY RELATED MATH AND MEASURING

OBJECTIVE 13

Add decimal numbers

Name _____ Score _____

INTRODUCTION

Metric measurements and money are both calculated as decimal numbers, the numbers to the right of the decimal being parts of a whole. Because they are parts of a whole, decimal numbers are sometimes called *decimal fractions* as opposed to proper fractions in which there is a numerator and denominator. Decimal fractions differ from proper fractions also in that they indicate units of 10s.

The automotive specialist today needs to be able to calculate metric measurements and determine the costs of parts and repairs. Every time specialists total the cost of a purchase or the sum of specific metric measurements, they are adding decimals.

Decimals are added just as whole numbers are added. You must be careful, though, to keep all decimal points aligned. Follow the steps below for adding decimal fractions.

Adding decimal numbers

1. Set up the problem as for addition of whole numbers, aligning decimal points directly under each other

   NOTE: Zeros may be added to ensure that units line up under units, tens under tens, and so on. Whole numbers have an understood decimal point to the right of the units digit: 7 is 7., 75 is 75., and 754 is 754., for instance.

   EXAMPLE: Add 0.857, 2.1, 753, and 370.057

   ```
     0.857          000.857
     2.1            002.100
   753       or     753.000
 + 370.057        + 370.057
   ```

2. Add each column of digits as for whole numbers

3. Locate the decimal point in the answer by placing it directly under the decimal points above

   EXAMPLE:

   ```
   000.857
   002.100
   753.000
 + 370.057
  1126.014    Answer
   ```

PART 1

Write the name of the place for each *underlined* digit.

_____ 1. 867.<u>4</u>3

_____ 2. 6.3<u>7</u>892

_____ 3. 1.0000<u>8</u>

_____ 4. 6.239<u>5</u>

_____ 5. 0.47<u>6</u>

Write the name of the place for the last digit in each of the following numbers.

_____ 1. 0.38

_____ 2. 0.4678

_____ 3. 321.9

_____ 4. 427.389

_____ 5. 44.67

Underline the digit that is in the place named in italics.

1. 46.3826 *Hundredths*
2. 35.0038 *Ten thousandths*
3. 148.296 *Tenths*
4. 6758.23 *Hundredths*
5. 91.4082 *Thousandths*
6. 204.37 *Tens*
7. 14.0079 *Ones (units)*
8. 208.097 *Hundredths*
9. 5.23981 *Thousandths*
10. 502.967 *Tenths*
11. 5230.867 *Thousandths*
12. 587.029 *Ones (units)*
13. 0.298 *Hundredths*
14. 329.768 *Tens*
15. 52.694 *Thousandths*
16. 498.276 *Tenths*
17. 0.5296 *Ten thousandths*
18. 468.539 *Hundreds*
19. 324.06 *Tenths*
20. 567.8 *Ones (units)*

352

PART 2

Set up the following groups of numbers in columns. Add each column, carrying when necessary and placing the decimal point correctly.

1. 0.024 + .165

2. 87.3 + 370

3. 15.127 + 3.4 + .0091 + 236.87

4. 195.7 + 83 + 9.006

5. .5280 + 435 + 179.50 + 1.9

PART 3

Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. Tom earned $22.50 on a repair job, and Mary earned $16.50. How much did they earn together?

   Total amount earned = _____

2. On a repair job, labor costs $54.65, parts cost $16.30, and the tax is $3.38. What is the total cost of the repair job?

   Total cost = _____

3. A technician worked four days on a certain project. She worked 6.8 hours Monday, 7.4 hours Tuesday, 5.3 hours Wednesday, and 4.4 hours Thursday. How many total hours did she work?

   Total hours worked = _____

4. Frank was cleaning out the storage bin. He found three partially used bottles of solvent, each containing the following amounts: 6.7 liters, 12.9 liters, and .5 liters. How many total liters of solvent were stored?

   Total liters of solvent = _____

5. In one month, an auto shop has the following expenses: engine parts, $286.96; transmission parts, $142.37; electric bill, $160.16; telephone, $116.27; and labor, $15,312.50. What was the shop's total monthly expenditure?

   Total monthly expense = _____

ASSIGNMENT SHEET 10

APPLY RELATED MATH AND MEASURING

OBJECTIVE 14

Subtract decimal numbers

Name _____ Score _____

INTRODUCTION

Decimals are a part of our daily lives, not only in figuring money but also in calculating time, distance, area, and many other quantities. In the automotive trade, decimals are becoming more common, especially with the increased use of metric measurements. Subtraction is one of the basic mathematical operations done with decimals in the trade. Follow the steps outlined below to subtract decimal numbers.

Subtracting decimal numbers

1. Set up problem as for subtraction of whole numbers, aligning decimal points directly under each other

   EXAMPLE: Subtract 1.397 from 8.120.

8.120	Original number
− 1.397	Subtracted number

2. Subtract each column of numbers as for whole numbers

3. Locate the decimal point in the answer by placing it directly under the decimal points above

4. Check your subtraction by adding your answer to the subtracted number

   NOTE: If you have solved the problem correctly, your check answer should be the same as the original number.

   EXAMPLE:

8.120	Original number
− 1.397	Subtracted number
+ 6.723	Answer (difference)
8.120	Check answer

PART 1

Set up each of the following problems in column form. Subtract and check your work. Show your work in the spaces provided.
Remember, when you subtract decimals, the decimal points must be aligned. Write your answers on the blanks.

1. 868.87 – 516.89 = _____

2. 567 – 19.856 = _____

3. 198 – 56.987 = _____

4. 567.94 – 59.78 = _____

5. $815.23 – $65.98 = _____

6. $20.03 – $15.88 = _____

7. 694.7 – 24.3 = _____

357

8. 5000 – 892.66 = _____

9. $15 – $12.53 = _____

10. $219.30 – $21.85 = _____

PART 2

Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. An auto shop received $8438.64 in December, and paid out $5121.32 in January. How much profit did the shop make?

   Profit = _____

2. It takes 20.5 hours to finish a job. Mark has worked 6 hours. How much longer will it take him to finish the job?

   Hours required to finish job = _____

3. A length of radiator hose 6.14 centimeters long was cut from a hose 8.98 centimeters in length. How much hose was left?

   Centimeters of hose left = _____

4. A fuel tank holds 49.2 liters of gasoline. After a trip about town to run errands, the driver determines that she has used 8.7 liters. How much gasoline was left in the tank?

   Liters of gasoline in tank = _____

5. A technician misread service manual suspension specifications and tightened the bracket mounting nuts to 27.5 Newton-meters required for the shock absorber mounting nuts rather than the 55 Newton-meters needed for the bracket mounting nuts. How many more Newton-meters must the bracket mounting nuts be tightened?

   Newton-meters = _____

ASSIGNMENT SHEET 11

APPLY RELATED MATH AND MEASURING

OBJECTIVE 15

Multiply decimal numbers

Name _____ Score _____

INTRODUCTION

Automotive specialists are often required to calculate the total charge for parts used for service or necessary repairs. Additionally, costs and earnings may be calculated by multiplying with decimals—an essential skill for any good automotive specialist.

Multiplication with decimals is similar to multiplication with whole numbers. However, with decimals you must take care in placing the decimal point correctly. The number of decimal places—those to the right of the decimal—in an answer must equal the total number of decimal places in the numbers that you multiplied. Follow the steps outlined below for multiplying decimal numbers.

Multiplying decimal numbers

1. Set up problem and multiply as for multiplication of whole numbers

   NOTE: Do **not** align the decimal points in columns when setting up multiplication problems for decimal numbers.

   EXAMPLE: Multiply 27.935 by 7.07.

   ```
     27.935   Original number
   x  7.07    Multiplier
   -------
     195545
    1955450
   -------
   19750045
   ```

2. Add the number of decimal places to the right of the decimal points in the multiplier and original number

   EXAMPLE:

   ```
     27.935          3   Decimal places
   x  7.07         +2   Decimal places
   -------         --
                    5   Total decimal places
   ```

3. Locate decimal point in answer by beginning at far right digit and counting off as many places to the left as the total decimal places found in step B

   EXAMPLE:

   ```
     27.935
   x  7.07
   -------
     195545
    1955450
   -------
   197.50045   = 5 Decimal places
   ```

PART 1

Set up the following problems in column form and multiply. Locate the decimal point in the answers. Show your work in the spaces provided. Write your answers on the blanks.

1. 2.64 × 3.1 = _____

2. 120 × 0.33 = _____

3. 2.25 × 0.51 = _____

4. 35 × 8.5 = _____

5. 26.4 × 3.8 = _____

6. 7.02 × 0.92 = _____

7. 0.83 x 0.55 = _____

8. 28.2 x 0.9 = _____

9. 0.069 x 0.01 = _____

10. 7.52 x 3.01 = _____

PART 2

Solve the following word problems. Show your work in the spaces provided. Write you answers on the blanks.

1. A tool kit is placed on sale for 25 percent off. By what amount is the price reduced if the regular price is $1349.80?

   NOTE: Twenty-five percent is the same as the decimal .25.

   Price reduction = _____

2. The average cost of a replacement part is $41.25. During the year, the technician installs 150 such parts. What was the total cost?

   Total average cost = _____

3. What is the total distance traveled at 1.3 km/h if the trip took .6 hours?

   Kilometers traveled = _____

4. What is the total length of 7 pieces of wiring if each piece is .04 meters long?

   Length in meters = _____

5. What is the cost of 15 gallons of gasoline at $1.13 per gallon?

   Cost = _____

6. If sparkplugs cost 78¢ each, what is the cost of 2 dozen plugs?

   Cost = _____

7. An auto shop is adding a service bay 16.4 meters long by 11.5 meters wide. How many square meters large will the bay be?

   Size in square meters = _____

8. Susan test drove 6 vehicles in the last five days. She drove 5.6 km the first day, 3.8 km the second day, 4.4 km the third day, 2 km the fourth day, and 6.6 km the fifth day. Using this five-day period as an average, how many kilometers would Susan drive over a 15-day period?

   Kilometers = _____

ASSIGNMENT SHEET 12

APPLY RELATED MATH AND MEASURING

OBJECTIVE 16

Divide decimal numbers

Name _____ Score _____

INTRODUCTION

An automotive specialist will usually have to shop around to find the best buys in tools and parts. Price comparisons often become difficult because not all suppliers base their prices on the same unit. Being able to divide decimal numbers will help a specialist determine the best buys. Division with decimal numbers is also useful in figuring quantities of materials, comparing wages, and in many other aspects of the trade.

Division with decimals is like division with whole numbers. However, before you begin to divide, you must decide where the decimal point should be placed in the number. Follow the steps outlined below for dividing decimal numbers.

Dividing decimal numbers

1. Set up problem as for division of whole numbers

   EXAMPLE: Divide 0.25 by 0.005.

   Divisor 0.005)0.25 Original number

2. Move the decimal point in the divisor to the right of the far right digit in the divisor

   EXAMPLE: 0.005.)0.25

3. Move the decimal point in the original number to the right by the same number of decimal places that you moved the decimal point in the divisor, adding zeros to the original number if necessary

   EXAMPLE: 0.005.)0.250.

   NOTE: If you are dividing a decimal number into a whole number, remember that whole numbers have an understood decimal point to the right of the units digit.

   EXAMPLE: 0.03)9 becomes 0.03.)9.00.

4. Place a decimal point in the answer space directly above the repositioned decimal point in the original number

   EXAMPLE: $0.005.\overline{)0.250.}$

5. Divide as for whole numbers

   EXAMPLE:
   $$0005.\overline{)0250.}\quad\begin{array}{r}50.\\ \\ \end{array}$$
   $$\begin{array}{r}025\\ 00\end{array}$$

6. Check your division by multiplying the original divisor (before decimal point was moved) by your answer and adding any remainder to this number

   NOTE: If you have solved the problem correctly, your check answer should be the same as the original number.

   EXAMPLE:

0.005	Divisor
× 50	Answer
0.250	Check answer (same as original number)

PART 1

Set up the following problems for division and divide accurately, placing the decimal in the correct position. Show your work in the spaces provided. Write your answers on the blanks.

1. 4.5 ÷ 0.5 = _____

2. 4.96 ÷ 0.4 = _____

3. 0.125 ÷ 0.25 = _____

4. 1.7608 ÷ 0.0062 = _____

5. 19.8 ÷ 0.6 = _____

6. 10.71 ÷ 0.07 = _____

7. 0.225 ÷ 0.15 = _____

8. 0.48 ÷ 0.6 = _____

9. 108 ÷ 0.09 = _____

10. 75 ÷ 0.03 = _____

PART 2

Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. A shipment of 114 water hoses has arrived at Mr. Smith's auto shop. Mr. Smith pays the carrier $544.98 for all of them. How much does 1 hose cost?

   Cost of 1 hose = _____

2. If a kilo of lubricant costs $7.95, how many kilos may be bought for $47.70?

   Number of kilos = _____

3. If a person can service the batteries in 32 automobiles in 3.9 days, how many automobiles can be serviced in 1 day?

   Number of automobiles serviced in 1 day = _____

4. How many jobs can be completed in 21.12 hours if the average job takes 0.66 hours?

   Number of jobs completed = _____

5. How many hours did an automobile specialist work if she was paid a total of $681.75 at the rate of $22.50 per hour?

Total hours worked = _____

ASSIGNMENT SHEET 13	APPLY RELATED MATH AND MEASURING

OBJECTIVE 17

Calculate correct amount of change due

Name _____ Score _____

INTRODUCTION

Businesses thrive and grow on fair profit, but a business must be accurate to earn a profit. For example, a net profit for a supermarket is only 1 to 2 percent; therefore, a 1-cent error practically wipes out profit. In addition, a business must be accurate to have good public relations. Customers simply will not return to a business that is not accurate in handling money. All employees who handle money in a business must be trained to be accurate.

Follow the steps below for learning to make change accurately and quickly.

Making change from money received from a customer

1. State amount of sale out of amount received from customer
2. Place amount received from customer on register's change ledge, and leave it there (not in drawer) until transaction is complete

   NOTE: If you leave the currency received on the change ledge, the customer will not be able to say he or she gave you a different denomination.
3. Repeat to yourself amount of sale from amount received, $6.19 out of $20.00 for instance
4. Build change to yourself, beginning with $6.19 and using as few coins and bills as possible
5. Close cash drawer partially
6. Begin the return change to customer by stating the amount of sale out of amount received
7. Build change in customer's hand from amount of sale, $6.19, to amount received, $20.00
8. Thank customer

9. Place $20.00 bill from change ledge into proper compartment in change drawer, face up, top of bill to right

10. Close cash register drawer

PART 1

Follow the steps in correctly handling money received from a customer to role-play making change for the following situations.

1. $3.67 out of $5.00
2. $2.98 out of $20.00
3. $ .51 out of $10.00
4. $4.51 out of $50.00
5. $1.26 out of $5.00
6. $7.57 out of $20.00
7. $7.43 out of $10.00
8. $51.42 out of three $20.00 bills
9. $26.89 out of two $10.00 bills and two $5.00 bills
10. $3.02 out of $20.02
11. $ .81 out of $1.00
12. $43.71 out of $100.00

PART 2

Compute the correct change for the following situations. Enter on the chart the number of coins and bills only, and use as few coins and bills as possible.

EXAMPLE: $2.71 out of $50.00

1¢	5¢	10¢	25¢	50¢	$1	$5	$10	$20	$50	Result
4			1		2	1		2		$47.29

Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	$10	$20	$50	Result
$5.47 out of $20.00											
$16.63 out of $20.00											
$ .38 out of $1.00											
$1.11 out of $2.00											
$13.22 out of $20.00											
$5.17 out of $10.00											
$36.36 out of $50.00											
$6.52 out of $20.00											
$ .78 out of $5.00											
$12.12 out of $20.00											

ASSIGNMENT SHEET 14

APPLY RELATED MATH AND MEASURING

OBJECTIVE 18

Convert fractions to decimals

Name _____ Score _____

INTRODUCTION

Machining parts, such as brake rotors and drums, often requires a greater degree of accuracy than that which can be measured with a fractional part of an inch. When specifications are given in hundredths, thousandths, and ten thousandths of a unit, the specialist must understand equivalent decimals.

Converting fractions to decimals

To convert a fraction to a decimal, simply divide the numerator by the denominator.

EXAMPLES: Convert 3/5 to a decimal.

$$5\overline{)3}$$

$$\begin{array}{r} .6 \\ 5\overline{)3.0} \\ \underline{3\,0} \\ 0 \end{array}$$

Convert 1/3 to a decimal.

$$3\overline{)1}$$

$$\begin{array}{r} .33 \\ 3\overline{)1.00} \\ \underline{9} \\ 10 \\ \underline{9} \\ 1 \end{array}$$

Any fraction that has a denominator of 10, 100, 1000, 10,000, or any other value that is obtained by multiplying 10 by itself a specified number of times is called a decimal fraction. To convert a decimal fraction to a decimal, simply count the number of zeros in the denominator, place a decimal that number of spaces to the left in the numerator (you will have to add zeros in some cases), and delete the denominator.

EXAMPLE: Convert $5\ 7/10$ to a decimal.

Since there is 1 zero in the denominator, you would move the decimal in the numerator one space to the left to get 5.7.

Sometimes you may want to round off a decimal number. To round off a decimal number, follow the steps outlined below.

Rounding decimal numbers

1. Find the place that you are rounding to

   EXAMPLE: 3.346
   Hundredths

2. If the digit to the right is 5 or more, add 1 to the place that you are rounding to; if it is less than 5, do not add anything

   EXAMPLE: 3.346
   5
   Five or more
   Add one.

3. Drop all of the digits to the right of the place that you are rounding to

   EXAMPLE: 3.35
   Digit dropped

PART 1

Convert each of the following fractions to a decimal. Show your work in the spaces provided. Write your answers on the blanks.

1. 1/8 = _____

2. 1/4 = _____

3. 1/16 = _____

4. 3/32 = _____

374

5. $^1/_2$ = _____

6. $^3/_4$ = _____

7. $^5/_8$ = _____

8. $^7/_8$ = _____

9. $^9/_{16}$ = _____

10. $^{15}/_{16}$ = _____

PART 2

Match the decimal numbers on the right to their equivalent fractions. Write the correct letters on the blanks.

_____	1. $5\frac{6}{10}$	a.	7.083
_____	2. $1\frac{2}{100}$	b.	5.006
_____	3. $\frac{87}{1000}$	c.	78.3
_____	4. $7\frac{83}{1000}$	d.	0.087
_____	5. $5\frac{6}{100}$	e.	0.783
_____	6. $5\frac{6}{1000}$	f.	87.7
_____	7. $78\frac{3}{10}$	g.	5.6
_____	8. $87\frac{7}{10}$	h.	102.0
_____	9. 102	i.	5.06
_____	10. $\frac{783}{1000}$	j.	1.02

PART 3

Write decimal equivalents for each of the following fractions.

1. $63\frac{9}{10}$ = _____
2. $5\frac{93}{100}$ = _____
3. $5\frac{93}{1000}$ = _____
4. $5\frac{93}{10000}$ = _____
5. $3\frac{825}{1000}$ = _____
6. $38\frac{95}{100}$ = _____
7. $38\frac{95}{1000}$ = _____
8. $42\frac{3}{10}$ = _____
9. $402\frac{3}{10}$ = _____
10. $897\frac{97}{1000}$ = _____

376

PART 4

NOTE: This symbol—≐—means "is about equal to."

► Round these decimals to the nearer:

Tenth

1. 2.36 ≐ _____
2. 4.23 ≐ _____
3. 2.06 ≐ _____
4. 4.109 ≐ _____
5. .072 ≐ _____

Hundredth

1. 14.023 ≐ _____
2. .067 ≐ _____
3. 1.089 ≐ _____
4. .4209 ≐ _____
5. 73.9029 ≐ _____

Thousandth

1. 5.0618 ≐ _____
2. 8.8397 ≐ _____
3. 8.0552 ≐ _____
4. 5.0168 ≐ _____
5. 78.0999 ≐ _____

► Complete the chart by rounding to the place named.

	Tenth	Hundredth	Thousandth
2.8354	2.8		
4.6215			
.2918			.292
.2065			
.1853		.19	
5.6356			
2.1523			
4.6652			

ASSIGNMENT SHEET 15

APPLY RELATED MATH AND MEASURING

OBJECTIVE 20

Read English and metric rules

Name _____ Score _____

INTRODUCTION

The American automotive industry is changing from the English system to the metric system. For this reason, you will find English/metric steel rules with an inch scale on one edge (graduated in sixteenths, thirty-seconds, or sixty-fourths) and a centimeter scale on the other side (graduated in millimeters). You must work with decimals and fractions to make accurate measurements with metric and inch rules.

Reading fractional measurements on an English rule

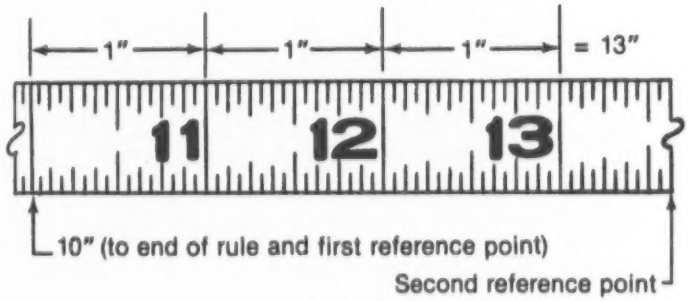
NOTE: All rules are read similarly. However, some rules are graduated with more divisions than others. The enlarged rule illustrated in Figure 1 below is graduated in sixty-fourths of an inch on the top scale and thirty-seconds of an inch on the bottom scale. The staggered graduations are for halves, quarters, eighths, sixteenths, and thirty-seconds.

FIGURE 1

1. Align the end of the rule with one reference point

2. Determine the number of whole units between the end of the rule and the second reference point

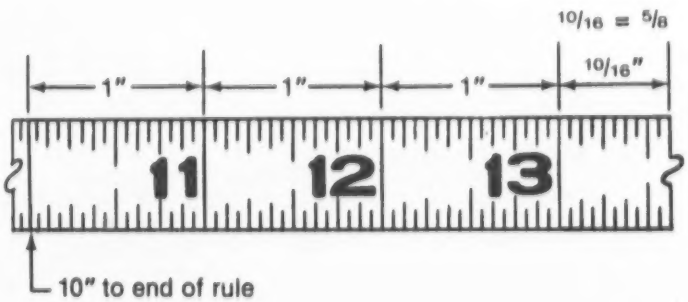
FIGURE 2



3. Determine the number of fractional units between the last whole unit and the second reference point by counting the divisions

4. Place this number over the rule scale (the rule in Figure 3 below is scaled in sixteenths of an inch) and reduce this fraction if possible

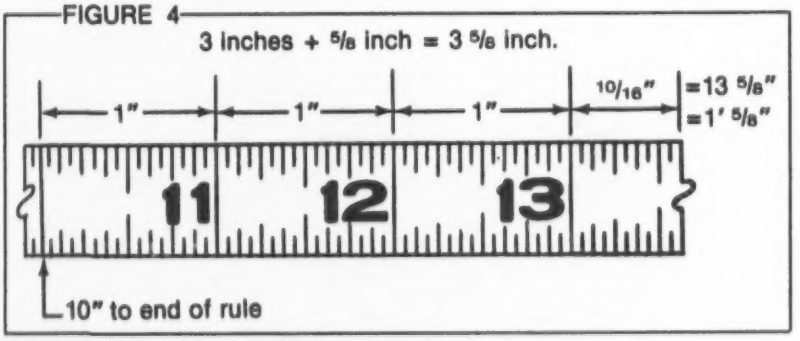
FIGURE 3



5. Make a mixed fraction by adding this reduced fraction to the number of whole units counted earlier; convert inches to feet if necessary by dividing 12 into the total whole inches measured

   EXAMPLE: 3 inches + 5/8 inch = 3 5/8 inch

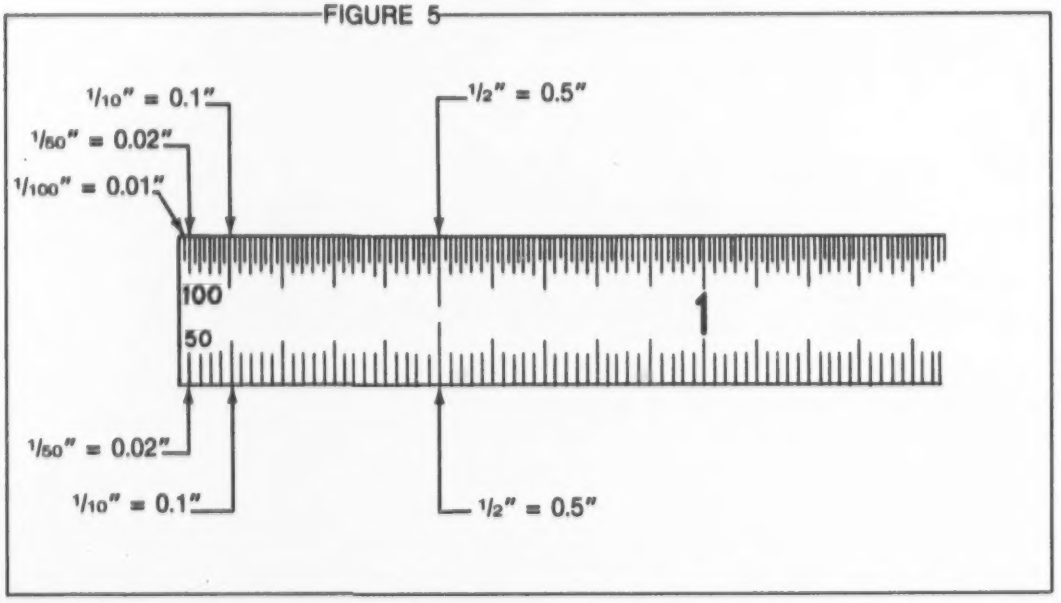
FIGURE 4



Reading decimal-inch measurements on an English rule

NOTE: English rules with decimal-inch increments allow for more precise measurements. The top scale on the enlarged rule illustrated in Figure 5 below is graduated in one-hundredths of an inch (0.01 inch). The bottom scale is graduated in fiftieths of an inch (0.02 inch). The staggered graduations are for halves, tenths, and fiftieths.

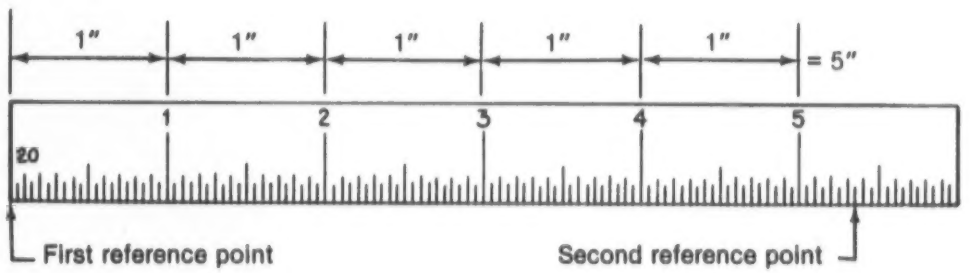
FIGURE 5



1. Align end of rule with one reference point
2. Determine number of whole units between end of rule and second reference point

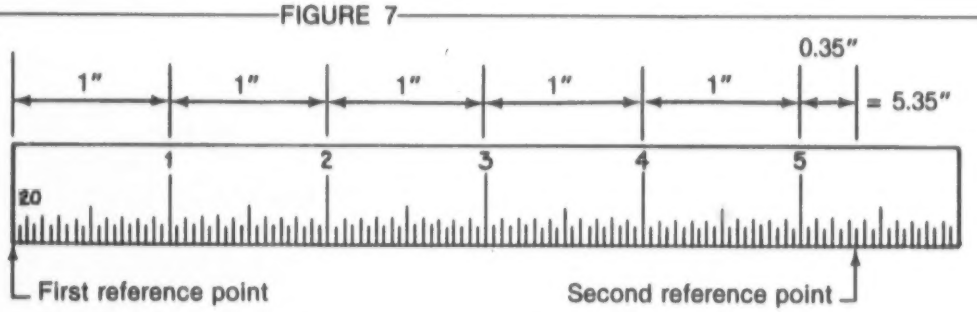
   NOTE: The rule illustrated in Figure 6 below is graduated in twentieths of an inch.

FIGURE 6



3. Count number of graduations (twentieths, 0.05 inch) between last whole unit and second reference point
4. Add this decimal fraction to number of whole units counted earlier

FIGURE 7



Reading a metric rule

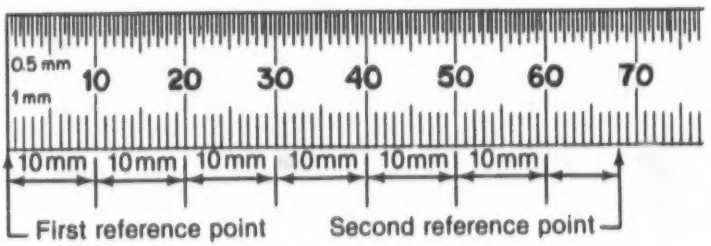
NOTE: Metric steel rules are available in a range from 150 millimeters to 1000 millimeters (1 meter) in length. The smallest graduation is 0.5 millimeter.

1. Align end of rule with one reference point

2. Determine number of whole units between end of rule and second reference point

NOTE: The enlarged metric rule illustrated in Figure 8 below is graduated in half millimeters (0.5) on the top and whole millimeters (1 mm) on the bottom scale.

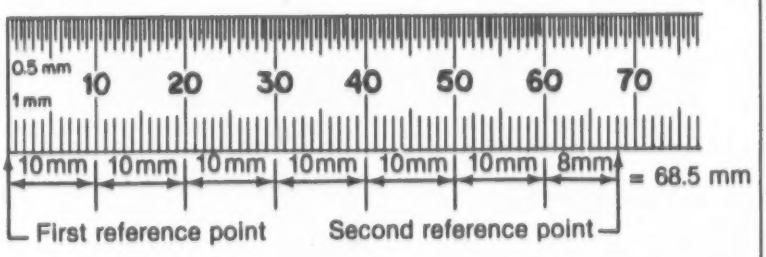
FIGURE 8



3. Count number of graduations (single and half millimeters) between last whole unit and second reference point

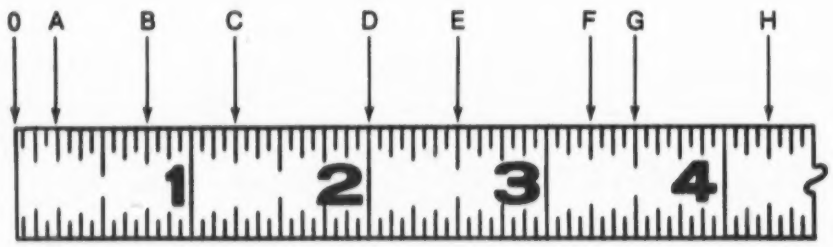
4. Add this number to the number of whole units counted earlier

FIGURE 9



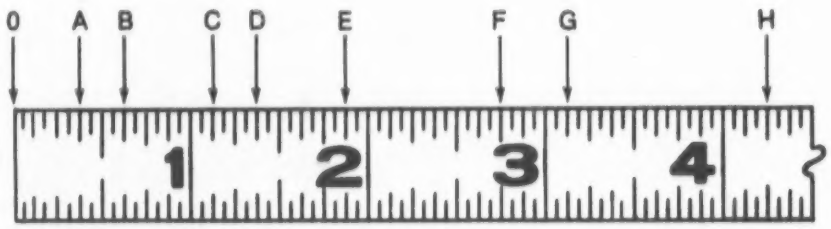
PART 1

Read the English rule illustrated below to the nearest quarter inch.
Write your answers on the blanks provided.



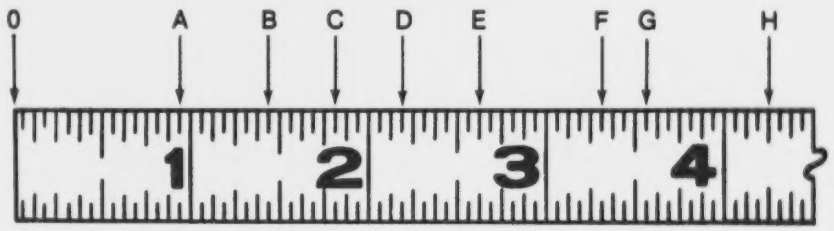
1. 0 to A = _____
2. A to B = _____
3. 0 to C = _____
4. A to D = _____
5. B to D = _____
6. 0 to E = _____
7. C to E = _____
8. B to F = _____
9. D to G = _____
10. A to H = _____

Read the English rule illustrated below to the nearest eighth inch.
Write your answers on the blanks provided.



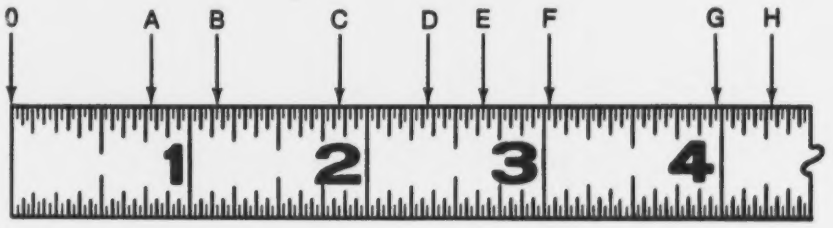
1. 0 to A = _____
2. A to B = _____
3. 0 to C = _____
4. B to D = _____
5. A to E = _____
6. 0 to F = _____
7. D to E = _____
8. C to G = _____
9. 0 to H = _____
10. E to H = _____

Read the English rule illustrated below to the nearest sixteenth inch. Write your answers on the blanks provided.



1. 0 to A = _____
2. A to B = _____
3. 0 to C = _____
4. B to D = _____
5. A to E = _____
6. 0 to F = _____
7. C to F = _____
8. A to G = _____
9. 0 to H = _____
10. E to H = _____

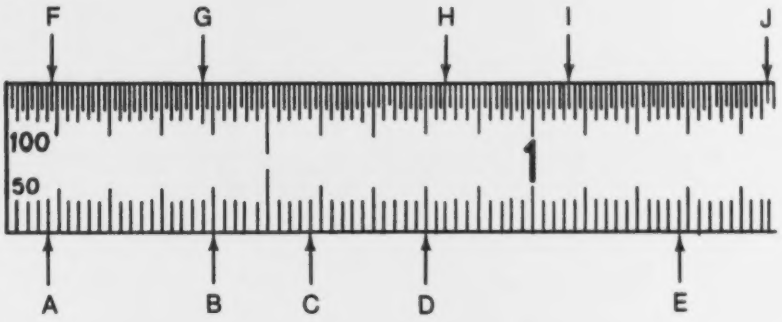
Read the English rule illustrated below to the nearest one thirty-second of an inch. Write your answers on the blanks provided.



1. 0 to A = _____
2. 0 to B = _____
3. A to B = _____
4. 0 to C = _____
5. A to D = _____
6. B to E = _____
7. C to F = _____
8. B to G = _____
9. 0 to H = _____
10. D to H = _____

PART 2

Read the English rule with decimal graduations in fiftieths and hundredths shown below. Write your answers on the blanks provided.



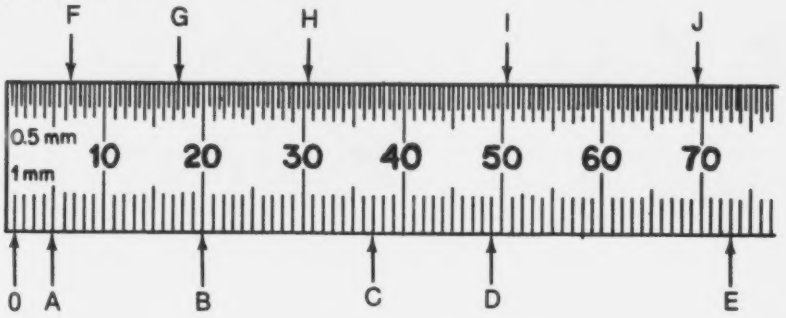
1. 0 to A = _____
2. 0 to B = _____
3. 0 to C = _____
4. 0 to D = _____
5. 0 to E = _____
6. 0 to F = _____
7. 0 to G = _____
8. 0 to H = _____
9. 0 to I = _____
10. 0 to J = _____

Read the English rule with decimal graduations in twentieths shown below. Write your answers on the blanks provided.

1. 0 to A = _____
2. 0 to B = _____
3. 0 to C = _____
4. 0 to D = _____
5. 0 to E = _____
6. 0 to F = _____
7. 0 to G = _____
8. 0 to H = _____
9. 0 to I = _____
10. 0 to J = _____

PART 3

Read the enlarged metric rule with 1-millimeter and 0.5-millimeter graduations shown below. Write your answers on the blanks provided.



1. 0 to A = _____
2. 0 to B = _____
3. 0 to C = _____
4. 0 to D = _____
5. 0 to E = _____
6. 0 to F = _____
7. 0 to G = _____
8. 0 to H = _____
9. 0 to I = _____
10. 0 to J = _____

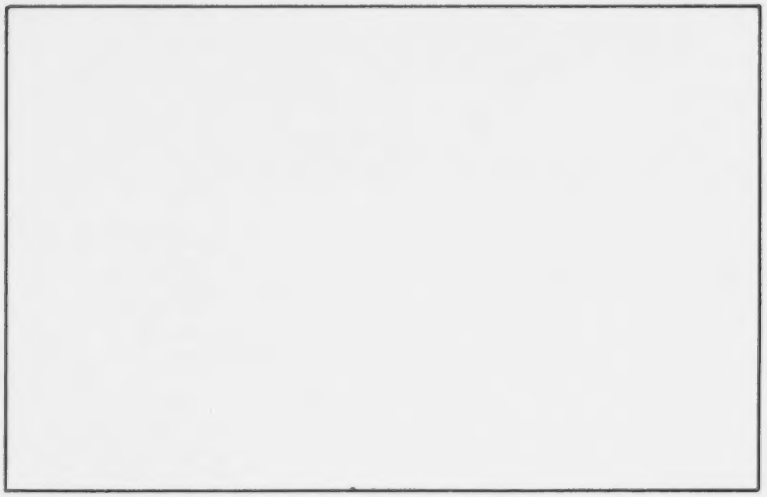
PART 4

Measure each of the following objects two times, first, with a rule graduated in sixteenths of an inch, and then with a metric rule graduated in 1-millimeter units. Write your answers on the blanks provided.

1.

Fractional Inch	*Metric*
Length = _____	Length = _____
Width = _____	Width = _____

2.

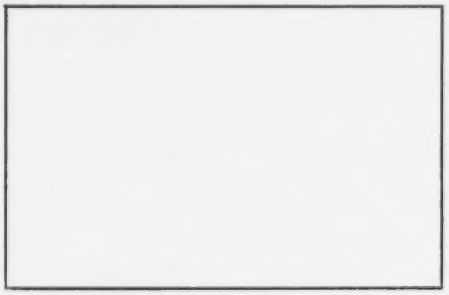


Fractional inch *Metric*

Length = _____ Length = _____

Width = _____ Width = _____

3.



Fractional inch *Metric*

Length = _____ Length = _____

Width = _____ Width = _____

Your instructor will indicate objects and components in the classroom and shop for you to measure. Measure each object with the different types of rules and write down the dimensions.

ASSIGNMENT SHEET 16	APPLY RELATED MATH AND MEASURING

OBJECTIVE 22

Read standard and metric micrometers

Name _____ Score _____

INTRODUCTION

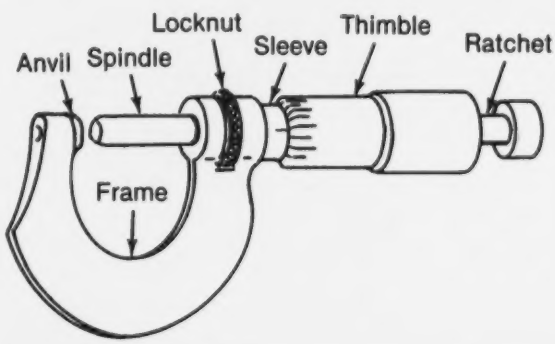
Micrometers are the measuring tools most commonly used by automotive specialists. Micrometers are used to measure accurately to 0.001 inch or 0.01 millimeter. The three basic types of micrometers are outside, inside, and depth micrometers. In this assignment sheet you will learn to read standard and metric inside and outside micrometers.

Reading outside micrometers

Outside micrometers come in a variety of sizes. Each one is used to measure only a particular range, so you must be sure to choose the proper size. Micrometer sizes 0 to 1 inch, 1 to 2 inches, 2 to 3 inches, and 4 to 5 inches are commonly used in the automotive trade. Regardless of the construction or size, the micrometer principle remains the same: The total measurement is equal to the sum of the reading on the barrel and sleeve.

If you have a standard micrometer available, refer to it while you read the following information, which explains how to read a micrometer. Figure 1 below shows the various parts of the typical outside micrometer.

FIGURE 1



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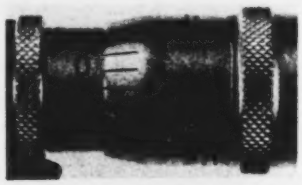
1. Note number on last vertical line visible on sleeve (each numbered line on sleeve represents a .100-inch increment)

2. Add .025 inch for each additional line that shows on sleeve

3. Add to this figure the number of graduation on thimble (there are 25 lines on the thimble, each equal to 0.001 inch)

4. Read the required reading as the sum of all additions; see the examples in Figure 2

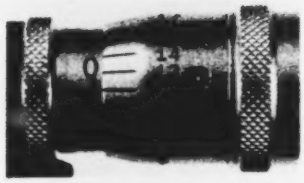
FIGURE 2



a. .000
b. .075
c. + .000
d. .075"

a. .100
b. .075
c. + .000
d. .175"

a. .200
b. .025
c. + .000
d. .225"



a. .000
b. .025
c. + .012
d. .037"

a. .500
b. .050
c. + .012
d. .562"

a. .900
b. .000
c. + .012
d. .912"

Reading metric micrometers

Metric-micrometer sizes 0 to 25 millimeters, 25 to 50 millimeters, and 50 to 75 millimeters are commonly used. Metric micrometers are read in the same manner as standard micrometers. The metric micrometer is graduated to read to an accuracy of 0.01 millimeter (equivalent to 0.0004 inch).

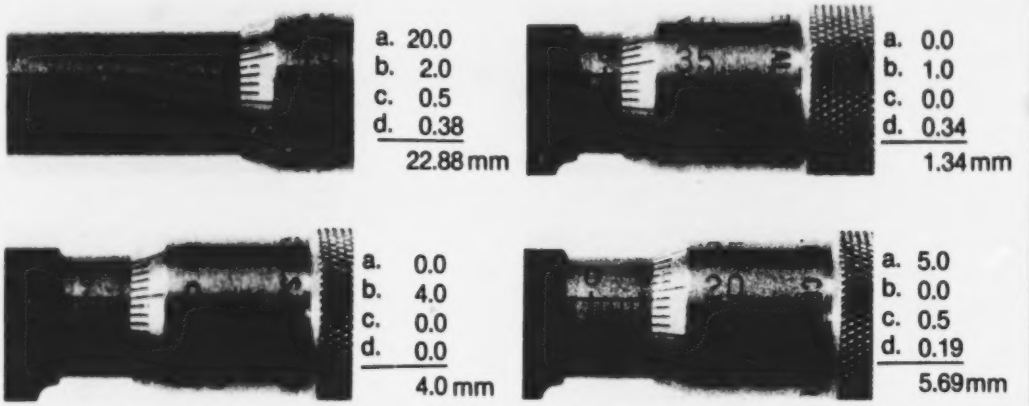
If you have a metric micrometer available, refer to it while you read the following information, which explains how to read a metric micrometer.

1. Note number on last vertical line visible on sleeve (each numbered line on sleeve represents a 5-millimeter increment)

2. Add 1 millimeter for each additional line that shows on top of sleeve above index line

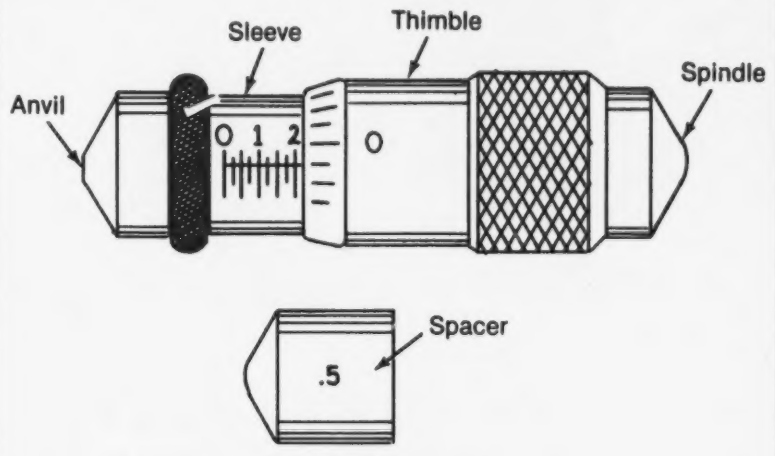
3. Add 0.5 millimeter for each additional line that shows on bottom of sleeve below index line
4. Add number of graduations on thimble (there are 50 lines on the thimble, each equal to 0.01 millimeter)
5. Read the required reading as the sum of all additions; see the examples in Figure 3

FIGURE 3



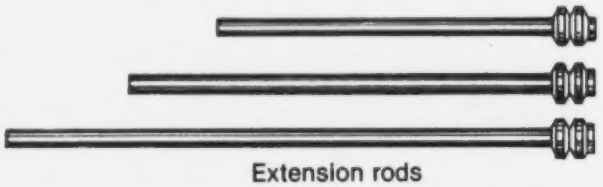
Reading inside micrometers (metric and customary)

FIGURE 4



The inside micrometer is read in exactly the same way as the outside micrometer. However, most inside micrometers have only .500 travel; a spacer of .500 is used to cover the remainder of the inch. Anything over 1 inch requires the use of extension rods; see Figure 5.

FIGURE 5

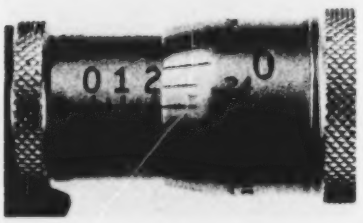


Extension rods

PART 1

Read the settings on the following English micrometers graduated in 0.001". Write your answers on the blanks.

_____ 1.

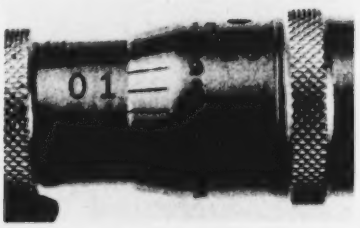


_____ 2.

_____ 3.

_____ 4.

_____ 5.

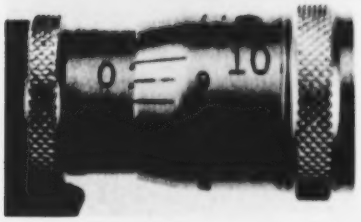


_____ 6.

392

_____ 7.

_____ 8.

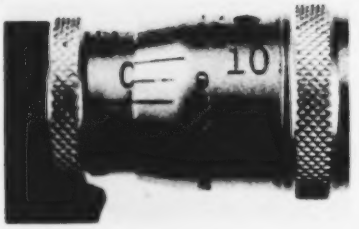


_____ 9.

_____ 10.

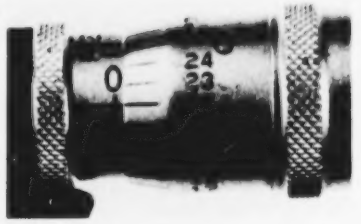
_____ 11.

_____ 12.



_____ 13.

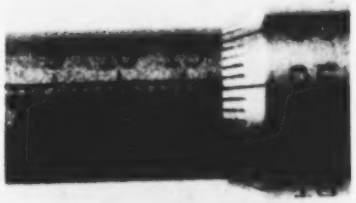
_____ 14.



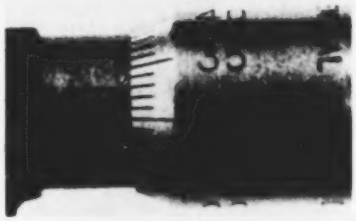
PART 2

Read the settings on the following metric micrometers graduated in 0.01 mm. Write your answers on the blanks.

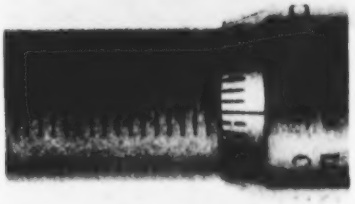
_____ 1.



_____ 2.



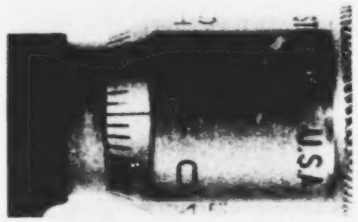
_____ 3.



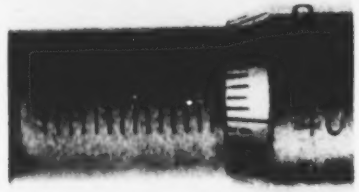
_____ 4.

_____ 5.

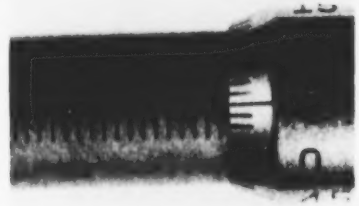
_____ 6.



_____ 7.

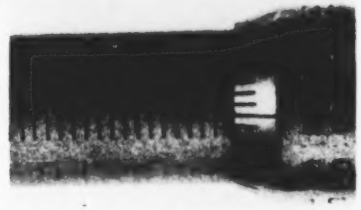


_____ 8.



_____ 9.

_____ 10.



ASSIGNMENT SHEET 17

APPLY RELATED MATH AND MEASURING

OBJECTIVE 25

Estimate angle sizes

Name _____ Score _____

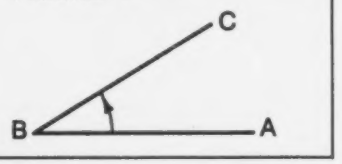
INTRODUCTION

The degree of precision required of a specialist in measuring and computing angles depends on how the angle is used. An automotive specialist may be asked to make caster and camber adjustments to within 1/2 or 1/4 degree, but may also be called on to install a part at approximately 90 degrees or hold a tool at a certain angle. The following guidelines will help you in being able to estimate angle sizes accurately.

GUIDELINES

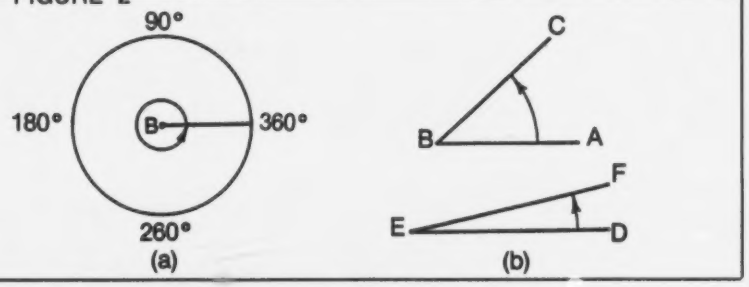
An angle may be thought of as two straight lines meeting at a point. Figure 1 shows an angle formed by two straight lines AB and BC meeting at point B.

FIGURE 1



If line BA is rotated, with a fixed endpoint at point B, one rotation makes a complete circle as point A sweeps through 360 degrees. See Figure 2-a.

FIGURE 2



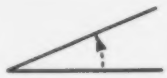
The size of an angle is determined by the amount of rotation (number of degrees) that would be necessary to move one of the sides of an angle onto the other. For example, in Figure 2-b the rotation from BA to BC would be greater than the rotation from ED to EF; therefore, angle ABC is larger than angle EDF.

In metric calculations, the decimal degree is generally the preferred unit of measurement. In the English system, angular measure may be expressed as decimal degrees (6.5 degrees), as fractional degrees (45 1/4 degrees), or as degrees, minutes, and seconds (37° 18′ 2″—thirty-seven degrees, 18 minutes, and 2 seconds).

Decimal and fractional degrees are added, subtracted, multiplied, and divided the same as any other number.

Angles are classified by the number of degrees in them. See Table 1 below.

TABLE 1: Angle classifications

Degrees	Kind of angle	Example
Between 0° and 90°	Acute	
90°	Right	
Between 90° and 180°	Obtuse	
180°	Straight	
Between 180° and 360°	Reflex	

PART 1

Use Table 1 above and your knowledge of basic mathematics to solve the following problems.

Give the correct name for each of the angles illustrated below. Write your answers on the blanks.

_____ 1. _____ 2.

Table 1 and the problems in Part 1 used with permission of Media Materials, Inc., Baltimore, Maryland, from *Basic Mathematics Skills*, by August V. Treff and Donald H. Jacobs, copyright © 1982.

3.

5.

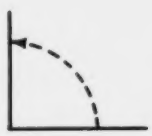
4.

6.

PART 2

Choose the closest number of degrees for each of the angles illustrated below. Write the correct letter on the blank.

____ 1.



a. 90°
b. 60°
c. 40°

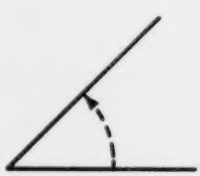
____ 3.

a. 5°
b. 10°
c. 20°

____ 2.

a. 180°
b. 160°
c. 270°

____ 4.



a. 35°
b. 45°
c. 65°

PART 3

Construct angles that approximate each of the following sizes.

1. 60°
2. 45°
3. 10°
4. 30°
5. 135°
6. 120°
7. 70°
8. 180°
9. 270°
10. 350°

ASSIGNMENT ANSWERS

APPLY RELATED MATH AND MEASURING

ASSIGNMENT SHEET 1

PART 1

1. 11	2. 16	3. 13
4. 23	5. 108	6. 88
7. 242	8. 1538	9. 1917
10. 16,430		

PART 2

1. 20	2. 84	3. 1135
4. $609	5. 86	6. 53
7. 31	8. 165	9. 12
10. 423		

ASSIGNMENT SHEET 2

PART 1

1. 4	2. 7	3. 53
4. 406	5. 424	6. 283
7. 1175	8. 1810	9. 51,450
10. 89,722		

PART 2

1. 126	2. 12	3. 22
4. 948	5. 38	6. 142
7. 210	8. 8	9. 113

10.

Week	1	2	3	4	5
Reading (start)	32,119	32,899	33,988	35,976	37,065
Reading (end)	32,899	33,988	35,976	37,065	39,001

Week 1 *780* km Week 4 *1089* km

Week 2 *1089* km Week 5 *1936* km

Week 3 *1988* km

ASSIGNMENT SHEET 3

PART 1

1. 42	2. 72	3. 324
4. 2884	5. 8410	6. 2028
7. 21,291	8. 165,478	9. 503,605
10. 5,458,852		

PART 2

1. 32	2. 96	3. 3000
4. 24	5. 128	6. $348
7. 315	8. 135	9. 1440
10. 15,042		

ASSIGNMENT SHEET 4

PART 1

1. 4	2. 8	3. 91
4. 312	5. 3	6. 3
7. 62	8. 21	9. 2
10. 3		

PART 2

1. 11	2. $22	3. 104
4. 23	5. $936	6. 33

ASSIGNMENT SHEET 5

PART 1

1. 1/2	2. 1/2	3. 1
4. 1/4	5. 1/3	6. 3/8
7. 1/2	8. 1 1/3	9. 2 1/2
10. 4 1/2		

ASSIGNMENT SHEET 6

PART 1

1. P	2. M	3. I
4. M	5. P	6. I
7. I	8. M	9. I
10. M	11. M	12. I
13. I	14. P	15. M

PART 2

1. 13/4	2. 9/2	3. 31/4
4. 17/2	5. 49/8	6. 11/2
7. 17/4	8. 19/2	9. 37/4
10. 33/2		

PART 3

1. 1 3/4	2. 4 1/2	3. 1 1/2
4. 1 7/8	5. 1 3/16	6. 1 3/8
7. 2 11/32	8. 2 1/2	9. 3 3/4
10. 2 1/16		

ASSIGNMENT SHEET 7

PART 1

1. 3/4
2. 1 1/2
3. 1/2
4. 1
5. 1 3/16
6. 25/32
7. 29/32
8. 1 1/4
9. 1 5/16
10. 1 25/32

PART 2

1. 14 3/4
2. 7 3/4
3. 7 3/16
4. 19 5/8
5. 13 1/16
6. 60 1/16
7. 6 13/16
8. 4 1/4
9. 17 1/16

ASSIGNMENT SHEET 8

PART 1

1. 9/16
2. 5/8
3. 3/16
4. 5/32
5. 3/4
6. 9/16
7. 1/16
8. 3/8
9. 17/32
10. 1/2

PART 2

1. 3 1/4
2. 6 1/16
3. 31 19/32
4. 174 1/5
5. 11 3/64

PART 3

1. 2/3
2. 1 5/8
3. 8 1/8
4. 1 11/32
5. 25 11/16
6. 7 1/4
7. 9/16
8. 1 1/16
9. 2/3
10. 38 9/16

PART 4

1. 2/5
2. 49 15/16
3. 5 2/3
4. 9 1/2
5. 27 1/8
6. 2 1/4
7. 2 1/8
8. 3 5/16
9. 2 1/2
10. 3 3/16

PART 5

1. 1/8
2. 3/4
3. 2 7/8
4. 10
5. 1 3/8
6. 6 11/20
7. 3 3/4
8. 8 5/8

9.

Shim	Outside diameter (D)	Single-wall thickness (T)	Inside diameter (X)
A	1	1/16	15/16
B	2 1/8	3/16	1 15/16
C	2 15/32	9/64	2 21/64
D	3 1/64	15/32	2 35/64
E	1 9/64	9/32	55/64

ASSIGNMENT SHEET 9

PART 1

1. Tenths
2. Hundredths
3. Hundred thousandths
4. Ten thousandths
5. Thousandths

1. Hundredths
2. Ten thousandths
3. Tenths
4. Thousandths
5. Hundredths

1. 46.3826
2. 35.0038
3. 148.296
4. 6758.23
5. 91.4082
6. 204.37
7. 14.0079
8. 208.097
9. 5.23981
10. 502.967
11. 5230.867
12. 587.029
13. 0.298
14. 329.768
15. 52.694
16. 498.276
17. 0.5296
18. 468.539
19. 324.06
20. 567.8

PART 2

1.
$$\begin{array}{r} 0.024 \\ +\ 0.165 \\ \hline 0.189 \end{array}$$

2.
$$\begin{array}{r} 87.3 \\ +\ 370.0 \\ \hline 457.3 \end{array}$$

3.
$$\begin{array}{r} 15.127 \\ 3.4 \\ .0091 \\ +\ 236.87 \\ \hline 255.4061 \end{array}$$

4.
$$\begin{array}{r} 195.7 \\ 83.0 \\ +\ 9.0006 \\ \hline 287.706 \end{array}$$

5.
$$\begin{array}{r} .5280 \\ 435. \\ 179.50 \\ +\quad 1.9 \\ \hline 616.9280 \end{array}$$

PART 3

1. $39.00
2. $74.33
3. 23.9
4. 20.1
5. $16,018.26

ASSIGNMENT SHEET 10

PART 1

1. 351.98
2. 547.144
3. 141.013
4. 508.16
5. 749.52
6. $4.15
7. 670.4
8. 4107.34
9. $2.47
10. $197.45

PART 2

1. $3317.32
2. 14.5
3. 2.84
4. 40.5
5. 27.5

ASSIGNMENT SHEET 11

PART 1

1. 8.184
2. 39.60
3. 1.1475
4. 297.5
5. 100.32
6. 6.4584
7. 0.4565
8. 25.38
9. 0.00069
10. 22.6352

PART 2

1. $337.45
2. $6187.50
3. .78
4. .28
5. $16.95
6. $18.72
7. 188.6
8. 336

ASSIGNMENT SHEET 12

PART 1

1. 9
2. 12.4
3. 0.5
4. 284
5. 33
6. 153
7. 1.5
8. 0.8
9. 1200
10. 2500

PART 2

1. $4.78
2. 6
3. 8.2
4. 32
5. 30.3

ASSIGNMENT SHEET 13

PART 1

1 through 12 — Instructor must observe student.

PART 2

Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	$10	$20	$50	Result
$5.47 out of $20.00	3				1	4		1			$14.53
$16.63 out of $20.00	2		1	1		3					$3.37
$ .38 out of $1.00	2		1		1						$ .62
$1.11 out of $2.00	4		1	1	1						$ .89
$13.22 out of $20.00	3			1	1	1	1				$6.78
$5.17 out of $10.00	3	1		1	1	4					$4.83
$36.36 out of $50.00	4		1		1	3		1			$13.64
$6.52 out of $20.00	3		2	1		3		1			$13.48
$ .78 out of $5.00	2		2			4					$4.22
$12.12 out of $20.00	3		1	1	1	2	1				$7.88

ASSIGNMENT SHEET 14

PART 1

1. 0.125
2. 0.25
3. 0.0625
4. 0.09375
5. 0.50
6. 0.75
7. 0.625
8. 0.875
9. 0.5625
10. 0.9375

PART 2

1. g
2. j
3. d
4. a
5. i
6. b
7. c
8. f
9. h
10. e

PART 3

1. 63.9
2. 5.93
3. 5.093
4. 5.0093
5. 3.825
6. 38.95
7. 38.095
8. 42.3
9. 402.3
10. 897.097

PART 4

Tenth

1. 2.4
2. 4.2
3. 2.1
4. 4.1
5. .1

Hundredth

1. 14.02
2. .07
3. 1.09
4. .42
5. 73.90

Thousandth

1. 5.062
2. 8.840
3. 8.055
4. 5.017
5. 78.100

	Tenth	Hundredth	Thousandth
2.8354	2.8	2.84	2.835
4.6215	4.6	4.62	4.622
.2918	.3	.29	.292
.2065	.2	.21	.207
.1853	.2	.19	.185
5.6356	5.6	5.64	5.636
2.1523	2.2	2.15	2.152
4.6652	4.7	4.67	4.665

ASSIGNMENT SHEET 15

PART 1

1. 1/4"
2. 1/2"
3. 1 1/4"
4. 1 3/4"
5. 1 1/4"
6. 2 1/2"
7. 1 1/4"
8. 2 1/2"
9. 1 1/2"
10. 4"

1. 3/8"
2. 1/4"
3. 1 1/8"
4. 3/4"
5. 1 1/2
6. 2 3/4"
7. 1/2"
8. 2"
9. 4 1/4"
10. 2 3/8"

1. 15/16"
2. 1/2"
3. 1 13/16"
4. 3/4"
5. 1 11/16"
6. 3 5/16"
7. 1 1/2"
8. 2 5/8"
9. 4 1/4"
10. 1 5/8"

1. 25/32"
2. 1 5/32"
3. 3/8"
4. 1 27/32"
5. 1 9/16"
6. 1 1/2"
7. 1 3/16"
8. 2 13/16"
9. 4 9/32"
10. 1 15/16"

PART 2

1. .08"
2. .40"
3. .58"
4. .80"
5. 1.28"
6. .09"
7. .38"
8. .84"
9. 1.07"
10. 1.45"

1. .15"
2. .50"
3. 1.25"
4. 1.80"
5. 2.85"
6. 3.95"
7. 4.35"
8. 4.95"
9. 5.35"
10. 5.85"

PART 3

1. 5 mm
2. 20 mm
3. 37 mm
4. 49 mm
5. 73 mm
6. 6.5 mm
7. 17.5 mm
8. 30.5 mm
9. 50.5 mm
10. 69.5 mm

PART 4

1. *Fractional inch* — *Metric*

   Length = 3" — Length = 76 mm

   Width = 1 15/16" — Width = 49 mm

2. *Fractional inch* — *Metric*

   Length = 4 5/16" — Length = 110 mm

   Width = 2 3/4" — Width = 70 mm

3. *Fractional inch* — *Metric*

   Length = 2 1/2" — Length = 63 mm

   Width = 1 5/8" — Width = 41 mm

ASSIGNMENT SHEET 16

PART 1

1. 0.223"
2. 0.949"
3. 0.520"
4. 0.388"
5. 0.157"
6. 0.520"
7. 0.589"
8. 0.083"
9. 0.738"
10. 0.808"
11. 0.797"
12. 0.008"
13. 0.679"
14. 0.022"

PART 2

1. 17.76 mm	2. 4.33 mm	3. 22.43 mm
4. 5.69 mm	5. 3.71 mm	6. 0.07 mm
7. 14.44 mm	8. 18.07 mm	9. 11.07 mm
10. 18.78 mm		

ASSIGNMENT SHEET 17

PART 1

1. Reflex	2. Right	3. Acute
4. Right	5. Straight	6. Obtuse

PART 2

1. a	2. b	3. a	4. b

PART 3

Evaluated by instructor

ACTIVITY SHEET 1

Work with fractions

Name _____

INTRODUCTION

Not only does the automotive specialist often use fractions for measurements, but much of the materials used in the automotive trade is sized in fractional units. For instance, tools, replacement parts, rivets, bolts, screws, and fasteners may all be sized in fractional units. The frequent use of fractions in the trade makes it necessary for the specialist to understand thoroughly how to work with fractions.

When something is divided into parts that are all the same size—or equal in size—it is divided into fractional parts. For example, the circle below is divided into four fractional parts.

To talk about fractional parts, you use fractions. For example, one of the four parts of the circle below is unshaded, or 1/4 of the circle is unshaded. Three of the four parts of the circle are shaded, or 3/4 of the circle is shaded.

In the fraction 3/4, the 4 is called the *denominator*. It shows the number of equal parts into which the circle is divided. The 3 is called the *nominator*. It shows the number of parts that are used.

PART 1

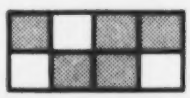
Fill in the blanks to identify the numerator and denominator of the following fractions.

1. In the fraction $\frac{5}{8}$, the numerator is _____ and the denominator is _____.
2. Write fractions to fit the following statements.
   a. A fraction with a denominator of 16 and a numerator of 10 is _____.
   b. A fraction with a numerator of 8 and a denominator of 32 is _____.

PART 2

Match the shaded portions of the following figures to the fractions they represent. Write the correct letters in the blanks.

_____ 1. $\frac{4}{8}$
_____ 2. $\frac{2}{2}$
_____ 3. $\frac{6}{16}$
_____ 4. $\frac{3}{8}$
_____ 5. $\frac{5}{8}$
_____ 6. $\frac{1}{2}$
_____ 7. $\frac{7}{16}$
_____ 8. $\frac{3}{4}$
_____ 9. $\frac{1}{4}$
_____ 10. $\frac{1}{8}$
_____ 11. $\frac{7}{8}$
_____ 12. $\frac{2}{4}$
_____ 13. $\frac{2}{8}$
_____ 14. $\frac{13}{16}$
_____ 15. $\frac{6}{8}$

a. 

b.

c.

d.

e.

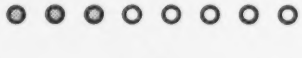
f.

g.

h.

i.

j.

k. 

l.

m.

n.

o.

409

PART 3

Tell whether the first fraction is less than (<) or greater than (>) the second fraction in each pair below.

1. $\frac{2}{3}$ $\frac{3}{4}$

2. $\frac{7}{8}$ $\frac{5}{6}$

3. $\frac{2}{7}$ $\frac{3}{9}$

4. $\frac{4}{7}$ $\frac{3}{8}$

5. $\frac{6}{8}$ $\frac{5}{6}$

6. $\frac{2}{3}$ $\frac{4}{7}$

7. $\frac{2}{9}$ $\frac{4}{7}$

8. $\frac{5}{8}$ $\frac{4}{7}$

9. $\frac{5}{15}$ $\frac{2}{3}$

10. $\frac{11}{15}$ $\frac{16}{17}$

11. $\frac{7}{8}$ $\frac{14}{18}$

12. $\frac{12}{17}$ $\frac{3}{4}$

13. $\frac{5}{17}$ $\frac{1}{3}$

14. $\frac{6}{11}$ $\frac{1}{5}$

15. $\frac{2}{13}$ $\frac{1}{6}$

16. $\frac{18}{19}$ $\frac{17}{18}$

ACTIVITY SHEET 2

Compute English/metric equivalents

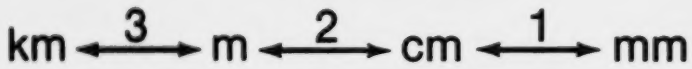
Name _____

INTRODUCTION

In the customary system of measurement, conversions from one unit to another are difficult because the units are so different. There are 5280 feet in a mile, 16 ounces in a pound, 2 cups in a pint, and 36 inches in a yard. Also, the units of measure are not easily related to each other. *One* gallon of water, for instance, weighs 8.345 pounds. In the metric system, however, the measurement units are all powers of ten, and units are all easily related to each other. *One* liter of water, for instance, weighs *one* kilogram.

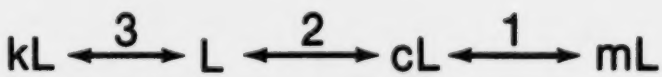
Converting from one metric unit to another

To convert from one metric unit to another, divide by 10, 100, 1000, etc. Because these conversion factors are all powers of 10, you can simply move the decimal point to the right or left instead of actually dividing or multiplying. Use the diagrams below to help you convert from one metric unit to another.



EXAMPLE: To change meters to centimeters, move the decimal point two places to the right: 5.2 m = 520 cm

To change millimeters to meters, move the decimal point 1 + 2, or 3 places to the left: 63 mm = .063 m



EXAMPLES: To change liters to kiloliters, move the decimal point 3 places to the left: 560 L = .56 kL

To change liters to milliliters, move the decimal point 2 + 1, or 3 places to the right: 7.6 L = 7600 mL

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To convert from English to metric or metric to English units of measure, use the conversion table in Student Supplement 3.

DIRECTIONS

Use the models above, the conversion table in Student Supplement 3, and your knowledge of basic math to compute the following problems.

- Fill in the missing numbers.

1. 4700 mL = _____ L
2. 8.2 kL = _____ L
3. 17,000 mL = _____ L
4. .036 km = _____ cm
5. 586 mm = _____ m
6. 784 m = _____ km
7. .0042 L = _____ mL
8. 43.6 cm = _____ m

- Tell whether you would use milliliters, liters, or kiloliters to measure each of the following items.

_____ 1. A can of brake fluid

_____ 2. Oil in a delivery truck

_____ 3. Amount of paint for refinishing an automobile

_____ 4. Water in a car's cooling system

_____ 5. A dose of medicine

_____ 6. Annual gas consumption in the United States

_____ 7. The amount of air in a tire

_____ 8. A teaspoon of grease

_____ 9. Brake fluid used by an auto shop in a week

_____ 10. Engine crankcase capacity

- Tell whether you would use millimeters, meters, centimeters, or kilometers to measure the following items.

_____ 1. Bolt size

_____ 2. Distance traveled in a month

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_____ 3. Piston bore size

_____ 4. Clearance between piston and bore

_____ 5. Micrometer extension rod length

_____ 6. Frame dimensions

_____ 7. Floor area in shop

_____ 8. Distance from shop to parts distributor

_____ 9. Length of a piece of chalk

_____ 10. Respirator strap size

- Use the conversion table formulas in Student Supplement 3 to convert the following English (customary) units to metric units of measure.

1. 14 gallons of gas = _____ L
2. 1.5 quarts of oil = _____ L
3. 20 pound-inches = _____ N-m
4. 10 miles = _____ km
5. 32 miles/gallon = _____ km/L
6. 2 yards = _____ m
7. 7 feet = _____ m
8. 1 ¾ inch = _____ mm
9. 180 horsepower = _____ kW
10. 60 miles per hour = _____ km/h

- Solve the following word problems.

1. An automobile travels from Town A to Town C by way of Town B. The car travels 135 kilometers. The trip takes 2.25 hours. It takes 0.8 hour to get from Town A to Town B. Assuming the same speed is maintained for the entire trip, how many kilometers apart are Town A and Town B?

   Answer = _____ km

2. An engine running at a constant speed uses 140 milliliters of gasoline per minute. How many liters of gasoline are used in 7 hours?

   Answer = _____ L

3. A component measures 993 millimeters. You need three such components and must place your order in total inches. How many inches would you order? What would be your order expressed in feet and decimal inches?

   Answer = _____ inches

   Answer = _____ feet _____ inches

ACTIVITY SHEET 3

Complete credit card transactions

Name _____

INTRODUCTION

Our world today is full of credit cards. These cards allow the customers to be billed for their purchases at a later date—rather than having to pay on the spot. As a gas-station attendant or worker at a parts distributorship or auto shop, you will probably have to handle credit cards just about every day. You should learn what credit cards your place of employment honors. Some gas stations have their own credit cards. For example, Texaco, Sunoco, Amoco, and Exxon each have their own special credit cards. Some common credit cards that are accepted at other automotive companies might include Bank Americard, Master Charge, VISA, and American Express. It might be a good idea to make a list of credit cards accepted by your company and post it by the cash register.

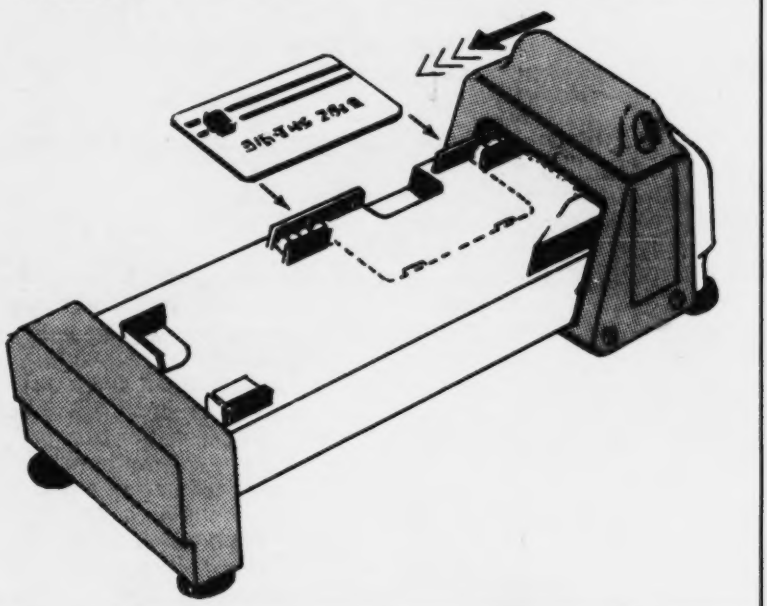
There is also another list that *must* be posted near the cash register. Credit card companies give out updated lists (called *warning bulletins*) of lost, stolen, or cancelled credit cards. Whenever a customer gives you a credit card, check the number on the card against the number on the warning-bulletin list. If the number is on the list, quietly notify your supervisor and he or she will take care of the situation.

After checking the warning bulletin, check the expiration date on the credit card. This date tells when the card expires or runs out. If it is past the date on the card, politely tell the customer that you cannot accept the card because it has expired, or follow your company's established procedures.

If a customer makes a purchase that costs more than a certain amount of money ($50 for instance), there are three things that you may have to do. First, you might have to ask for the customer's driver's license and match the name on the license with the name on the credit card. Second, you might have to get approval from your manager in order to accept the credit card. A third possibility is that you may have to call the credit card agency for approval. These procedures are different for different places of employment, so check with your manager or supervisor to be sure of what to do.

A small machine is used with credit cards to record on a sales draft the customer's name, account number, expiration date, and sometimes the name of your place of employment. The machine, called an *imprinter*, looks something like the one in Figure 1 on the next page.

FIGURE 1



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In addition to completing the paperwork and imprinting the sales draft, you will need to complete several important steps to make sure that the card is valid and that the transaction is within your company's policies. This activity sheet will help you learn to complete credit card transactions.

EQUIPMENT AND MATERIALS

- Credit cards
- Imprinter
- Sales drafts
- Pen or pencil
- Warning bulletins

PROCEDURE

1. Check the card
   a. Check to see that it is a card your company accepts
   b. Check to see that the card has **not** expired
   c. Check to see that the card has been signed
   d. Check the card for signs of mutilation or alteration
2. *If* the card is acceptable, continue with the procedures; *if* the card is **not** acceptable, politely inform the customer and follow your company's policies for handling the situation

3. Imprint the card onto a sales draft

   a. Prepare the imprinter for the transaction

      NOTE: Some imprinters, such as those used in many service stations, also imprint the total amount of the transaction. The clerk must dial in this amount before imprinting the card. Other imprinters mark the date. Be sure that the date is correct before using the imprinter.

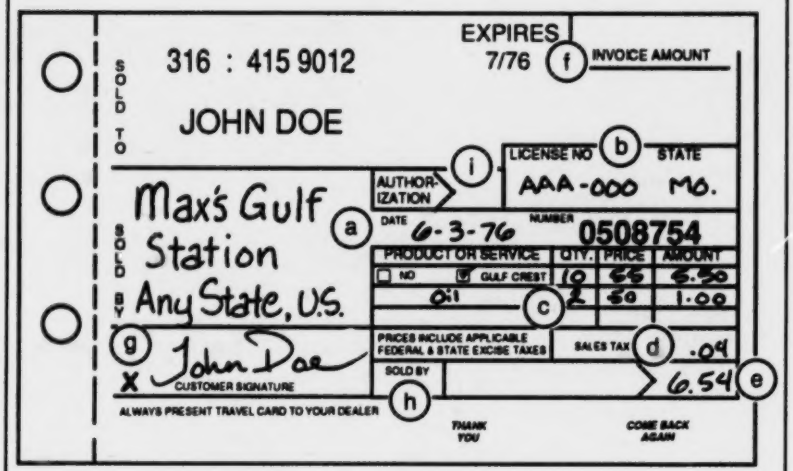
   b. Place the credit card in the imprinter face up

   c. Place the sales draft, face up, on top of the card

   d. Push the imprinter handle all the way across the sales draft and slide it back again

      NOTE: As the bar presses down on the sales draft and card, the raised letters on the card are transferred onto the draft through two layers of carbon paper. The resulting sales draft will look similar to the one below in Figure 2.

FIGURE 2



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4. Remove the sales draft and check the imprint

   a. Compare the sales draft to the credit card to be sure that the customer's name, account number, and expiration date show legibly and completely

   b. Check to see that other imprinter information such as company name and member number show

      NOTE: Most companies have policies for how to handle drafts that do not imprint properly. Some businesses allow the clerk to write in illegible information, while others require that the transaction be redone. Some companies even require that the invalid sales draft be marked and saved.

5. Fill in the sales draft with the following information as labeled in Figure 2 above

   NOTE: The sales draft above is typical of one used for gas purchases in a gas station. Slips used in other places of business will be similar but will not contain a place for license plate number.

   a. Date of sale, unless imprinted by machine

   b. Customer's license plate number (if service station purchase)

   c. Check off or write in type of product or products sold to customer, quantity sold, price per unit, required codes

   d. The tax, from tax chart or cash register if computed by cash register

   e. The total, unless imprinted by machine

   f. Other information as required

      NOTE: Some businesses require additional information that may or may not be shown on the sales draft. For example, some companies may require the clerk to write on the sales draft the invoice number, the customer's telephone number, or some other identification number.

6. Have customer sign the sales draft (See "g" on Figure 2)

7. Compare the signatures on the credit card and the sales draft

   NOTE: *If* the signatures or names do **not** compare, follow your company's policies for this situation.

8. Check the warning bulletins to see that the card account number is **not** listed

   NOTE: *If* the card is listed, follow your company's policies for this situation.

9. *If* the transaction is acceptable except for the need for additional authorization, initial the block labeled SOLD BY (See "h" on Figure 2)

10. Seek further authorization as required by company policy

    NOTE: Authorization may be required for various reasons for all or just some credit card transactions. For example, authorization may be required if the purchase exceeds a given amount. Authorization may be within the company such as by a manager or outside the company by the credit agency.

11. Fill in the AUTHORIZATION block or have your manager initial it (See "i" on Figure 2)

12. Tear off the customer's copy and return it to the customer along with the credit card

13. Ask the customer whether he or she wants the carbons or whether you should destroy them

    NOTE: The carbons contain all the information on the credit card and should be handled in light of this confidential information. Give them to the customer or tear them in two and place them in a trash receptacle.

14. Place your copy of the sales draft in the appropriate place in the cash register

    CAUTION

    To your company, the credit card sales draft is just as valuable as money. It must be returned to the credit card agency for credit.

DIRECTIONS

Your instructor will provide you with a variety of credit cards and sales drafts. Choose a partner and properly complete a number of credit card transactions until you become proficient.

ACTIVITY ANSWERS

APPLY RELATED MATH AND MEASURING

ACTIVITY SHEET 1

PART 1

1. 5, 8
2. a. $^{10}/_{16}$ b. $^{8}/_{32}$

PART 2

1. n	2. d	3. f	4. k
5. a	6. j	7. i	8. l
9. b	10. g	11. m	12. c
13. h	14. o	15. e	

PART 3

1. $\frac{2}{3} < \frac{3}{4}$	7. $\frac{2}{9} < \frac{4}{7}$	12. $\frac{12}{17} < \frac{3}{4}$
2. $\frac{7}{8} > \frac{5}{6}$	8. $\frac{5}{8} > \frac{4}{7}$	13. $\frac{5}{17} < \frac{1}{3}$
3. $\frac{2}{7} < \frac{3}{9}$	9. $\frac{5}{15} < \frac{2}{3}$	14. $\frac{6}{11} > \frac{1}{5}$
4. $\frac{4}{7} > \frac{3}{8}$	10. $\frac{11}{15} < \frac{16}{17}$	15. $\frac{2}{13} > \frac{1}{6}$
5. $\frac{6}{8} < \frac{5}{6}$	11. $\frac{7}{8} > \frac{14}{18}$	16. $\frac{18}{19} > \frac{17}{18}$
6. $\frac{2}{3} > \frac{4}{7}$		

ACTIVITY SHEET 2

1. 4.7	2. 8200	3. .017	4. 3600
5. .586	6. .784	7. 4.2	8. .436

1. liters	2. kiloliters	3. liters
4. liters	5. milliliters	6. kiloliters
7. liters	8. milliliters	9. liters
10. liters		

1. millimeters	2. kilometers	3. centimeters
4. millimeters	5. centimeters	6. meters
7. meters	8. kilometers	9. centimeters
10. centimeters		

1. 52.99	2. 1.4	3. 2.24	4. 16.09
5. 13.6	6. 1.7	7. 0.644	8. 1129.1
9. 134.28	10. 96.54		

1. 48	2. 58.8	3. 118.26
		9, 10.55

JOB SHEET 1	APPLY RELATED MATH AND MEASURING

OBJECTIVE 23 — **Use inside and outside micrometers**

INTRODUCTION

The automotive specialist uses micrometers when relatively high-precision measurements are required. The specialist may use a micrometer to measure rotor thickness, camshaft diameter, piston diameter, engine cylinder bores, and many other components.

There are many different types and sizes of micrometers. English micrometers are available in sizes from 0.5 inch to 60 inches. Metric micrometers are available in sizes up to 600 millimeters.

Because micrometers are precision instruments, they must be treated with care. Follow the guidelines below for caring for micrometers.

- Keep micrometer free of dust, grit, and grease.
- Keep micrometer in a case or box when not being used, and do not store micrometer with other tools.
- If micrometer is dropped, do not use it again until it has been checked for accuracy against a standard. It may need to be adjusted.
- If micrometer needs cleaning, wipe it with light machine oil and a soft lint-free cloth. This will also help prevent corrosion.

EQUIPMENT AND MATERIALS

- Standard and metric inside-micrometer set with extension rods
- Standard or metric outside micrometer
- Micrometer manufacturer's instructions
- Pencil and paper for recording results
- Lint-free cloth and light machine oil
- Piece of brake line and wheel cylinder of known dimensions
- Steel rule
- Automotive components to be measured (selected by instructor)

PROCEDURE

For outside micrometer

1. Select correct-sized micrometer for component you are measuring
2. Check component to be sure that it is free of nicks, burrs, or dents
3. Apply light machine oil to lint-free cloth and gently clean micrometer spindle and anvil (See Figures 1 and 2)

FIGURE 1

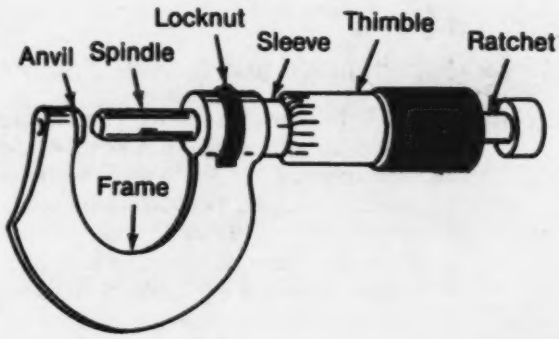
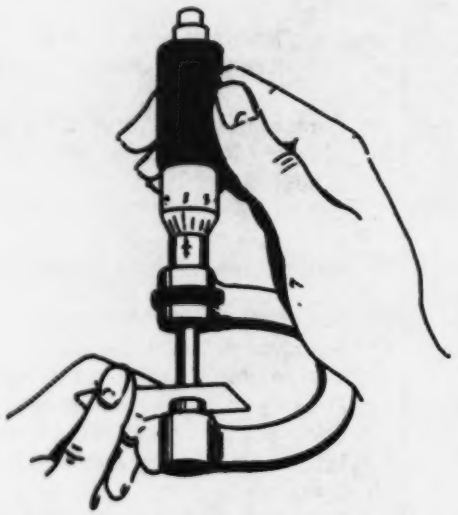


FIGURE 2

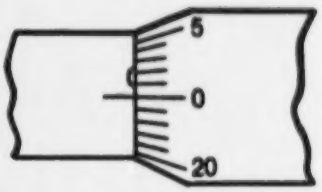


4. Check micrometer at zero reference

   a. Rotate thimble until spindle just touches anvil, and then turn ratchet until several clicks are heard

   b. Check to see that reference line on sleeve and zero on thimble match up as shown in Figure 3 on the next page

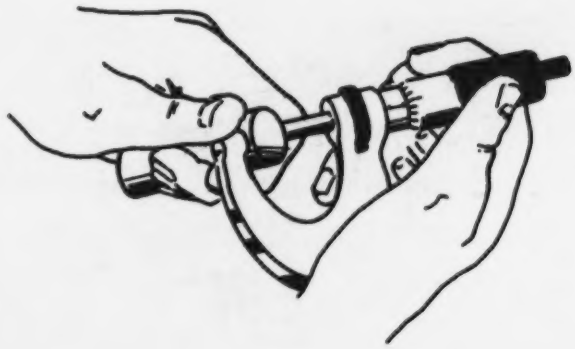
FIGURE 3



5. Hold micrometer according to type of component being measured

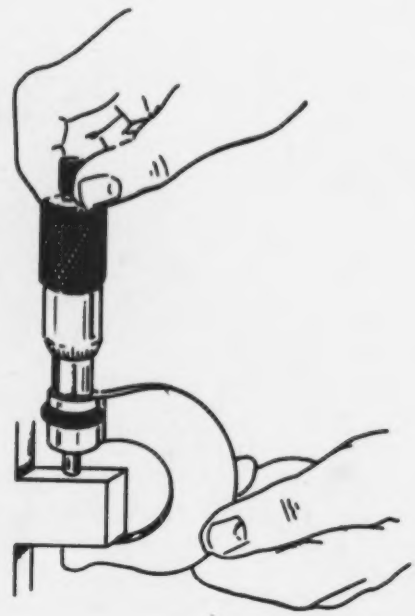
   a. To measure a nonstationary object, hold micrometer in one hand and component in other as shown in Figure 4

FIGURE 4



   b. To measure a stationary object, hold micrometer in both hands as shown in Figure 5 on the next page

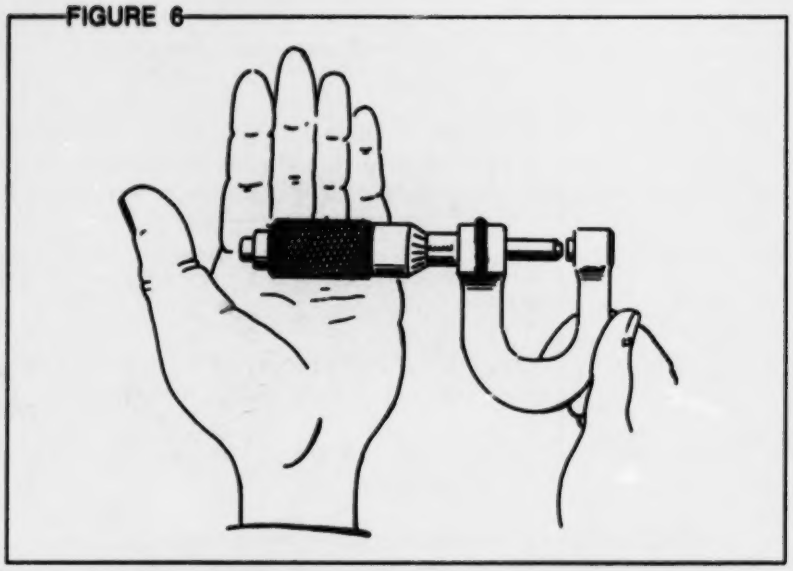
FIGURE 5



6. Roll micrometer along palm of hand or forearm for quick adjustment (See Figure 6), and then place directly over center of component to be measured

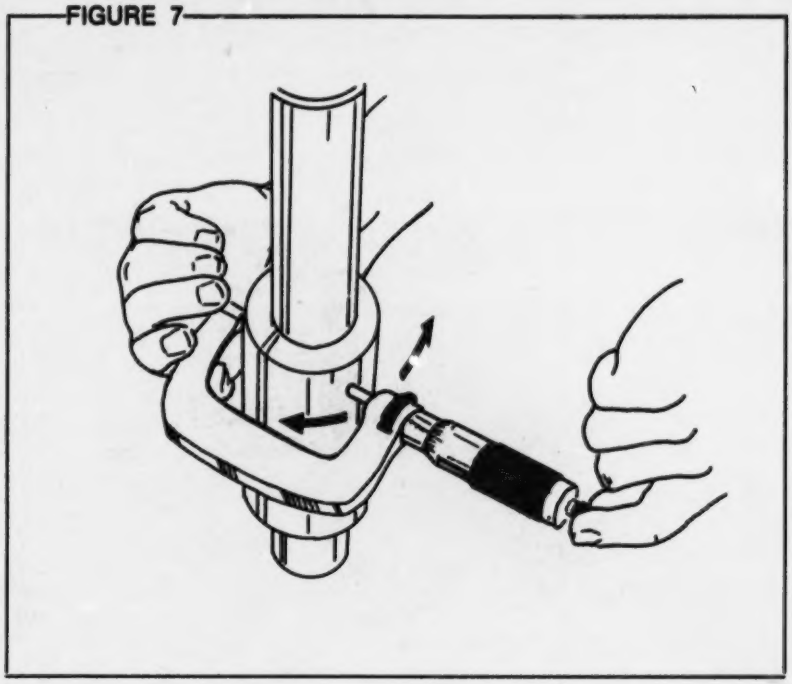
   NOTE: Before measuring a component selected by the instructor, check the accuracy of the micrometer by measuring the outside diameter of a piece of brake line that has a standard dimension. *If* the micrometer reading and the standard dimension are **not** the same, test and use another micrometer.

FIGURE 6



7. Twist thimble between your thumb and first finger, stopping when spindle just touches component to be measured
8. Hold anvil steady and move spindle lightly over component to locate true center line (Figure 7)

FIGURE 7



9. If micrometer has a ratchet stop to adjust tightness, turn it until you hear at least two clicks

10. Take reading while component is still in micrometer; *if* this is not possible, use locknut to lock spindle at correct reading and then carefully remove micrometer from component and read measurement (Assignment Sheet 16)

11. Repeat this process on a number of automotive components until you become proficient at using and reading an outside micrometer

12. Clean micrometer with a lint-free cloth and return it to its correct storage, leaving the spindle and anvil open for storage

13. Clean work area and return equipment and materials to proper storage

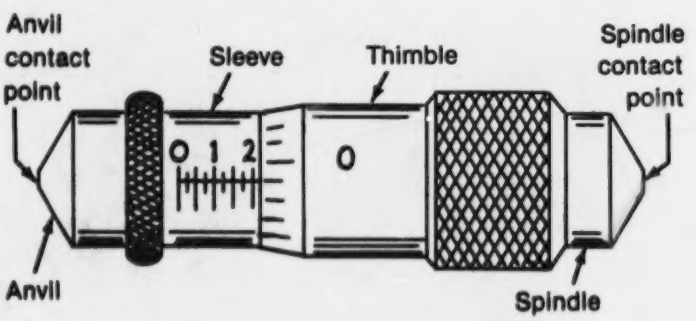
PROCEDURE

For using an inside micrometer

1. Check component to be measured to be sure that it is free of nicks, burrs, or dents

2. Apply light machine oil to a lint-free cloth and gently clean anvil and spindle contact points and micrometer accessories (Figure 8)

FIGURE 8



3. Check micrometer at zero reference to be sure that reference line on sleeve and zero on thimble match

4. Use a steel rule to measure approximate inside diameter of component to be measured

5. *If* necessary, select correct extension rod and collar for required measurement

6. *If* necessary, select extension collar to utilize full range of extension rod

7. *If* necessary, select extension handle for small-hole or deep-hole application

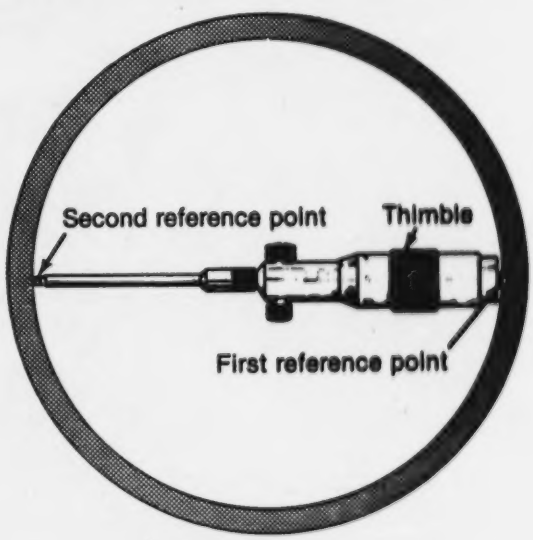
8. Follow micrometer manufacturer's instructions and use proper tools to assemble accessories on micrometer

9. Place micrometer inside component to be measured, and establish reference point for spindle contact point (See Figure 9)

   NOTE: Before measuring a component selected by the instructor, check the accuracy of the micrometer by measuring the inside diameter of a wheel cylinder that has a standard dimension. *If* the micrometer reading and the standard dimension are **not** the same, test and use another micrometer.

10. While holding micrometer steady with spindle contact point on reference point, rotate thimble until anvil contact point just touches component wall to establish second reference point (Figure 9)

FIGURE 9



11. Move spindle contact point from side to side to find true inside diameter of component

12. *If* possible, read micrometer while inside component; *if* this is **not** possible, the micrometer locks automatically and may be withdrawn from component for reading

13. Read micrometer (Assignment Sheet 16); add to this reading the length of extension rod and collar if applicable

14. Repeat this process on the inside diameters of a number of automotive components until you become proficient at using and reading an inside micrometer

15. Disassemble accessories from micrometer, if necessary; clean micrometer with a soft lint-free cloth; and place in proper storage

16. Clean work area and return equipment and materials to proper storage

JOB SHEET 2

APPLY RELATED MATH AND MEASURING

OBJECTIVE 24

Measure tire and wheel runout

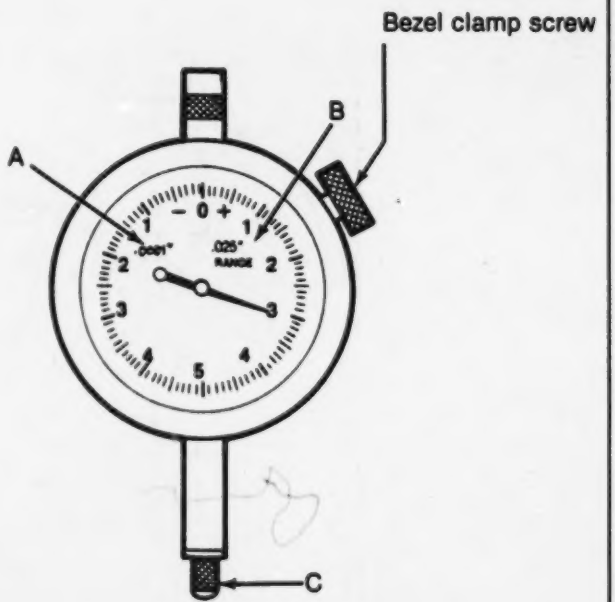
INTRODUCTION

In order to determine the condition of a tire, it is sometimes necessary to perform a tire and wheel runout check. This is a relatively simple procedure that accurately determines whether a tire will perform as designed.

Tire and wheel runout can be measured with a runout gauge or a dial indicator. A dial indicator is preferred over a runout gauge as it will give a more accurate reading. Dial indicators are precision instruments designed to measure small amounts of movement. They may be graduated in thousandths of an inch or hundredths of a millimeter.

An automotive specialist should be able to take a correct reading from a dial indicator. Refer to the dial indicator illustrated in Figure 1 below as you read the following information on making a correct reading.

FIGURE 1



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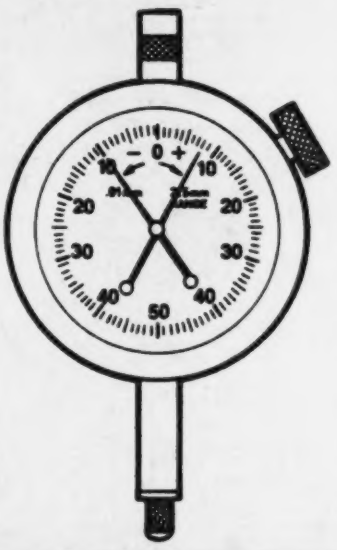
The size of the smallest graduation on the dial is given by the number labeled *A* in Figure 1. On this dial indicator, each graduation is one ten thousandths of an inch. The range number, labeled *B* in Figure 1, shows the largest dimension the indicator can measure. This relates to the amount of movement possible by the stem, *C*, within the indicator. On the dial indicator in Figure 1, the range is twenty-five thousandths of an inch. The same type of information is found on metric dial indicators. The indicator above may be red with the pointer moving either left or right.

To make a reading, check the size of the smallest graduation and count. The numbered graduations are usually thousandths. Thus, the reading on the dial indicator in Figure 1 is 0.0031 inch. Had the pointer been pointing to the same graduation on the left side of the indicator, the reading would have been −0.0031 inch.

Remember the following guidelines when reading a dial indicator:

- On some indicators, the pointer can go around two and one-half times without a counter. To keep track of the readings, you must count the revolutions of the pointer.
- For some dial-indicator uses, you must measure what is called *total* (or *full*) *runout*. This occurs when the pointer moves both in the plus and minus directions. To get total dial-indicator runout, you must add the readings in both directions. An example is shown in Figure 2 below. The total runout is .10 mm plus .08 mm, which equals .18 millimeters.

FIGURE 2



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- The bezel and dial may be rotated to set the zero on the dial under the pointer in any position. The bezel clamp screw (see Figure 1) then holds the new position.

EQUIPMENT AND MATERIALS

- Floor jack and jack stands
- Dial indicator
- Chalk
- Pencil and paper for recording results
- Large base on which to mount dial indicator
- Chalk
- Eye protection
- Appropriate shop manual
- Tire pressure gauge
- Torque wrench

PROCEDURE

1. Check tire inflation pressure against that specified in service manual; inflate tires to correct pressure if necessary

2. Check lug-bolt torque; torque to specifications if necessary

3. Test brakes, and then drive vehicle several miles to heat up the tires

4. Raise vehicle on floor jack and support safely with jack stands

   NOTE: Perform tire and wheel runout measurement procedure as soon after driving the vehicle as possible. This is necessary to avoid a false reading due to the tendency of tires to take a temporary "set" after standing for a period of time.

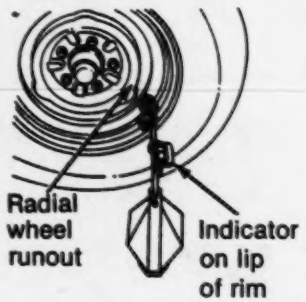
5. Clean dirt and gravel from wheel and tire assembly

6. Mount dial indicator on large base, following manufacturer's instructions

7. Check radial runout with indicator

   a. To measure *wheel* radial runout, mount indicator on wheel inner lip as shown in Figure 3 on the next page

FIGURE 3



b. Rotate wheel slowly by hand, observing gauge reading through one complete turn; record reading

c. Mark wheel with chalk at any point gauge reading exceeds 0.035 inch or 0.85 millimeter

d. To measure *tire* radial runout, remove indicator from wheel inner lip, place strip of masking tape around tire tread near center of tire (See Figure 4), and mount indicator on tape on tire tread as shown in Figure 5

NOTE: Tape provides a more even surface for the dial indicator to ride on.

FIGURE 4

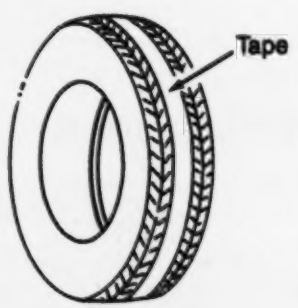
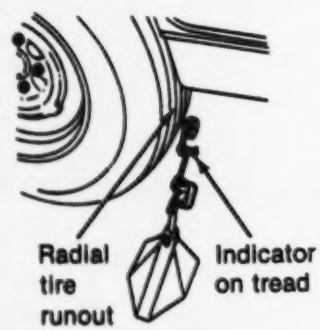


FIGURE 5



e. Rotate wheel slowly by hand, observing gauge reading through one complete turn; record reading

f. Mark wheel with chalk at any point gauge reading exceeds 0.050 inch or 1.27 millimeters

8. Check lateral runout with indicator

   a. To measure *tire* lateral runout, mount indicator on tire sidewall as shown in Figure 6

FIGURE 6

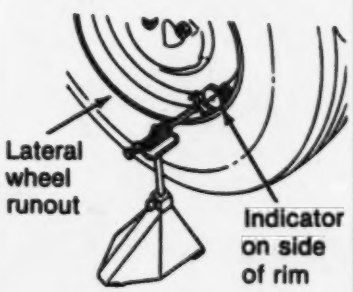
   b. Rotate wheel slowly by hand, observing gauge reading through one complete turn; record reading

   c. Mark wheel with chalk at any point gauge reading exceeds 0.050 inch or 1.27 millimeters

   d. To measure *wheel* lateral runout, remove indicator from tire sidewall and mount on side of rim as shown in Figure 7

      NOTE: Check rim for welds or nicks that can damage the dial indicator.

FIGURE 7



Figures 3, 5, 6, and 7 used with permission of Chrysler Motors Corporation.

   e. Rotate wheel slowly by hand, observing gauge reading through one complete turn; record reading

f. Mark wheel with chalk at any point gauge reading exceeds 0.050 inch or 1.27 millimeters

9. Replace the wheel if there are any chalk marks on either lateral or radial runout areas

NOTE: Rims that are not bent severely may be straightened if a special machine is available.

10. Replace tire only after it has been determined that wheel is true and tire is out of limits

NOTE: Some manufacturers recommend rotating the tire 180 degrees on the rim and rechecking runout before replacing the tire.

11. Lower vehicle to floor

12. Clean work area and return equipment and materials to proper storage

JOB SHEET 3

APPLY RELATED MATH AND MEASURING

OBJECTIVE 26

Measure tire-tread depth

INTRODUCTION

Tire service and maintenance is one of the most important aspects of automotive service. Without proper tire maintenance, a vehicle can become unsafe for the highway. With proper tire service, the vehicle handles better at both high and low speeds because the brakes and steering components work better.

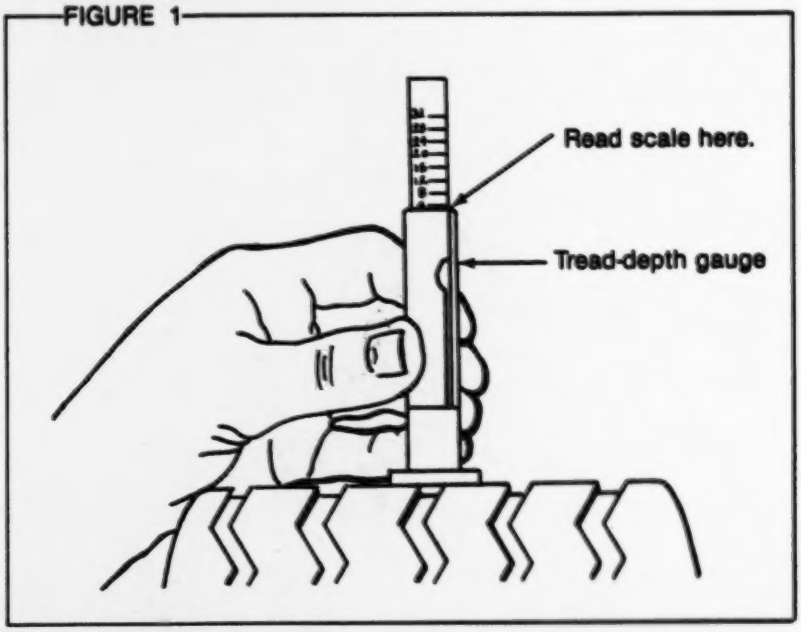
EQUIPMENT AND MATERIALS

- Tread-depth gauge
- Floor jack or hydraulic lift
- Jack stands
- Pencil and paper for recording results

PROCEDURE

1. Raise vehicle and support safely
2. Visually inspect all four tires for normal tread wear
3. Measure amount of tread remaining on tires
   a. Place tread-depth gauge on most worn place on tire as shown in Figure 1

FIGURE 1



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b. Press scale plunger down into groove between tire ribs

c. Read scale (to the nearest 1/32 inch) at point that it emerges from gauge

d. Record reading

e. Rotate tire and take readings at two or three other worn locations, recording reading for each location

f. Repeat measuring procedure for other three tires

4. Replace tire if the remaining tread depth measures less than 2/32 (1/16) inch

   NOTE: Most vehicle inspection laws read: "Reject any tire that is so worn that less than 2/32-inch tread remains when measured in any two grooves at three equally spaced intervals around the circumference of the tire."

5. Lower vehicle to floor

6. Clean work area and return equipment and materials to proper storage

PRACTICAL TEST

APPLY RELATED MATH AND MEASURING

JOB SHEET 1

Use inside and outside micrometers

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Inspected component to be measured for nicks, burrs, or dents.	_____	_____
3. Prepared micrometer for service.	_____	_____
4. Checked micrometer at zero reference.	_____	_____
5. Positioned micrometer correctly according to component being measured.	_____	_____
6. Followed correct procedure for measuring component and obtained correct reading.	_____	_____
7. Cleaned micrometer and returned to proper storage.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper component/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

APPLY RELATED MATH AND MEASURING

JOB SHEET 2

Measure tire and wheel runout

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Checked tire inflation pressure against manufacturer's specifications.	_____	_____
3. Prepared vehicle for procedure.	_____	_____
4. Correctly mounted dial indicator, following manufacturer's instructions.	_____	_____
5. Followed correct procedure for checking radial runout.	_____	_____
6. Followed correct procedure for checking lateral runout.	_____	_____
7. Correctly determined wheel condition.	_____	_____
8. Correctly prepared vehicle for service.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper component/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

APPLY RELATED MATH AND MEASURING

JOB SHEET 3

Measure tire-tread depth

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Raised and properly supported vehicle.	_____	_____
3. Performed visual inspection of tires.	_____	_____
4. Followed proper procedure for measuring tire-tread depth.	_____	_____
5. Correctly determined tire condition and replaced tire as required.	_____	_____
6. Properly lowered vehicle.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper component/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST

APPLY RELATED MATH AND MEASURING

Name _____ Score _____

OBJECTIVE 1

Choose the definition that best defines the following terms associated with math and measuring. Write the correct numbers in the blanks.

_____a. **Whole number (integer)**

1. Any one of the ten symbols, 0 to 9, by which all numbers can be expressed
2. Any of the natural numbers, both positive and negative, that represent a complete item
3. Part of a whole; represents one or more equal parts of a unit

_____b. **Digit**

1. Any one of the ten symbols, 0 to 9, by which all numbers can be expressed
2. Any of the natural numbers, both positive and negative, that represent a complete item
3. Part of a whole; represents one or more equal parts of a unit

_____c. **Fraction**

1. Any one of the ten symbols, 0 to 9, by which all numbers can be expressed
2. Any of the natural numbers, both positive and negative, that represent a complete item
3. Part of a whole; represents one or more equal parts of a unit

_____d. **Decimal**

1. One part in a hundred; reckoned on the basis of a whole divided into one hundred parts
2. Any of the natural numbers, both positive and negative, that represent a complete item
3. Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

_____e. **Addition**

1. Process of totaling two or more numbers to find another number called a *sum*
2. Abbreviated process of adding a number to itself a specified number of times
3. Process of reducing one number by taking another number away from it

_____f. **Subtraction**

1. Opposite operation of multiplication
2. Opposite operation of addition
3. Opposite operation of division

_____g. **Multiplication**

1. Relationship in quantity, amount, or size between two or more things
2. Process of totaling two or more numbers to find another number called a *sum*
3. Abbreviated process of adding a number to itself a specified number of times

_____h. **Division**

1. Opposite operation of multiplication
2. Opposite operation of subtraction
3. Opposite operation of addition

_____i. **Percent**

1. Fraction with an unwritten denominator of 10 or some power of 10
2. One part in a hundred; reckoned on the basis of a whole divided into one hundred parts
3. Relationship in quantity, amount, or size between two or more things

_____j. **Ratio**

1. Fraction with an unwritten denominator of 10 or some power of 10
2. Being relatively equal in size or quantity
3. Relationship in quantity, amount, or size between two or more things

_____k. **Meter**

1. Metric unit used to measure capacity
2. Metric unit used to measure length
3. Metric unit used to measure mass or weight

_____l. **Liter**

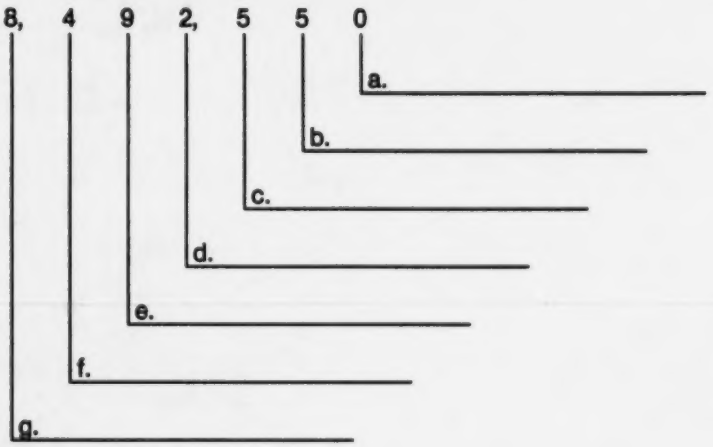
1. Metric unit used to measure mass or weight
2. Metric unit used to measure capacity
3. Metric unit used to measure length

_____m. **Gram**

1. Metric unit used to measure length
2. Metric unit used to measure capacity
3. Metric unit used to measure mass or weight

OBJECTIVE 2

Label the place values of the following whole number. Write how much each digit is worth in the blanks.



OBJECTIVE 3 Add the following whole numbers.

a. 9721 + 8854

b. 4071 + 0917 + 2349

c. 98 + 89 + 54 + 72

d. 140 + 538 + 691 + 555 + 096

e. 4,987,620 + 9,472,118 + 4,823,379

OBJECTIVE 4 Subtract the following whole numbers.

a. 9721 − 8854

b. 2349 − 0407

c. 198 − 79

d. 579 − 278

e. 67,540 − 17,609

OBJECTIVE 5 Multiply the following whole numbers.

a. 9 × 7

b. 12 × 6

c. 179 × 89

d. 4280 × 25

e. 198 × 198

OBJECTIVE 6

Divide the following whole numbers. Show your work and label your remainders with an "R."

a. $34\overline{)217}$

b. $12\overline{)144}$

c. $83\overline{)9836}$

d. $712\overline{)482{,}018}$

OBJECTIVE 7

Distinguish among the following types of fractions. Write a "P" in the blanks before proper fractions, an "I" before improper fractions, and an "M" before mixed numbers.

_____a. $\frac{1420}{1240}$ _____b. $\frac{11}{12}$ _____c. $\frac{3}{4}$

_____d. $\frac{33}{100}$ _____e. $\frac{10}{8}$ _____f. $41\frac{1}{2}$

_____g. $\frac{42}{24}$ _____h. $1\frac{3}{16}$ _____i. $\frac{34}{1000}$

_____j. $\frac{11}{10}$

OBJECTIVE 8

Reduce the following fractions to their lowest terms.

a. $^{6}/_{9}$ = _____

b. $^{5}/_{25}$ = _____

c. $^{16}/_{64}$ = _____

d. $^{40}/_{16}$ = _____

e. $^{81}/_{9}$ = _____

f. $^{24}/_{16}$ = _____

g. $^{4}/_{32}$ = _____

h. $^{72}/_{8}$ = _____

i. $^{250}/_{1500}$ = _____

OBJECTIVE 9

Convert the following mixed numbers to improper fractions and the following improper fractions to mixed numbers.

Convert mixed numbers to improper fractions

a. $4\ ^{3}/_{8}$ = _____

b. $8\ ^{5}/_{6}$ = _____

c. $7\ ^{1}/_{2}$ = _____

d. $9\ ^{5}/_{16}$ = _____

e. $5\ ^{3}/_{4}$ = _____

Convert improper fractions to mixed numbers

a. $^{8}/_{4}$ = _____

b. $^{7}/_{7}$ = _____

c. $^{5}/_{3}$ = _____

d. $^{65}/_{32}$ = _____

e. $^{33}/_{8}$ = _____

OBJECTIVE 10

Add the following fractions and reduce to lowest terms. Show your work. Write your answers on the blanks.

a. $1/16 + 9/16 =$ _____

b. $7/8 + 5/8 + 3/8 =$ _____

c. $1/4 + 3/8 =$ _____

d. $7\ 15/16 + 2\ 1/4 + 5/8 =$ _____

e. $1\ 5/16 + 5\ 1/4 + 25/32 =$ _____

OBJECTIVE 11

Subtract the following fractions and reduce to lowest terms. Show your work. Write your answers on the blanks.

a. $7 - \frac{3}{4} =$ _____

b. $1\frac{5}{8} - \frac{1}{4} =$ _____

c. $4\frac{9}{16} - 1\frac{15}{32} =$ _____

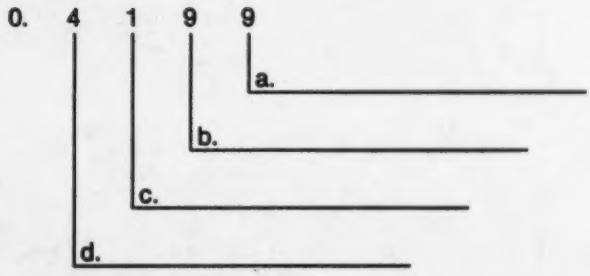
d. $5\frac{1}{4} - 3\frac{5}{8} =$ _____

e. $\frac{7}{16} - \frac{5}{16} =$ _____

450

OBJECTIVE 12

Label the place values of the following decimal number.



OBJECTIVE 13

Add the following decimal numbers. Show your work. Write your answers on the blanks.

a. 0.34 + 81.0 + 0.165 = _____

b. 54.34 + 12.01 = _____

c. .9908 + 195.5 + 8.8 = _____

d. 34.67 + .0016 + 2.1 = _____

e. $143.27 + $312,367.12 + $483.98 + $4.15 = _____

OBJECTIVE 14

Subtract the following decimal numbers. Show your work. Write your answers on the blanks.

a. 654.1 – 437.89 = _____

b. 21.4 – 18.1 = _____

c. 1.00 – 0.25 = _____

d. 5491.87 – 3888.98 = _____

e. $42,564.07 – $37,982.98 = _____

OBJECTIVE 15

Multiply the following decimal numbers. Show your work. Write your answers on the blanks.

a. 56.833 × 0.04 = _____ b. 1.98 × .67 = _____

c. 3338.78 × 0.359 = _____ d. .6629 × 11.53 = _____

e. 1234 × 3.98 = _____

OBJECTIVE 16

Divide the following decimal numbers. Show your work.

a. $0.341\overline{)25.89}$ b. $2.8\overline{)490}$

OBJECTIVE 17 Calculate the correct change for the following problems. Use as few coins and bills as possible, and enter the number of coins and bills only.

	Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	$10	Result
a.	$2.76 out of $5.00									
b.	17¢ out of 50¢									
c.	$1.29 out of $20.00									
d.	$6.98 out of $10.00									
e.	39¢ out of $1.09									
f.	81¢ out of $5.00									
g.	$4.79 out of $20.00									

OBJECTIVE 18 Convert the following fractions to decimals. Show your work in the space provided. Round your answer to the nearest hundredth. Write your answers on the blanks.

a. $9/16$ = _____

b. $7/8$ = _____

c. $1/4$ = _____

d. $5\ 3/4$ = _____

e. $9\ 3/32$ = _____

f. $72\ 3/10$ = _____

g. $5\ 93/1000$ = _____

h. $1\ 2/100$ = _____

i. $15\ 5/6$ = _____

OBJECTIVE 19

Recall the values of prefixes associated with metric measurement by writing the correct values for the following metric terms.

_____ a. Centimeter (c)

_____ b. Milliliter (mL)

_____ c. Kilometer (Km)

_____ d. Hectogram (hg)

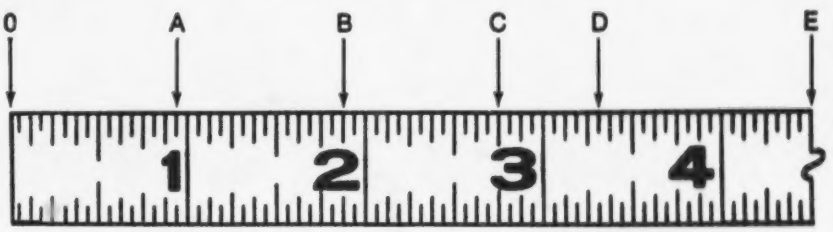
_____ e. Decimeter (dm)

_____ f. Dekaliter (daL)

OBJECTIVE 20

Read the English and metric rules illustrated below. Write your answers on the blanks provided.

English rule (Read to the nearest sixteenth inch.)



a. 0 to A = _____

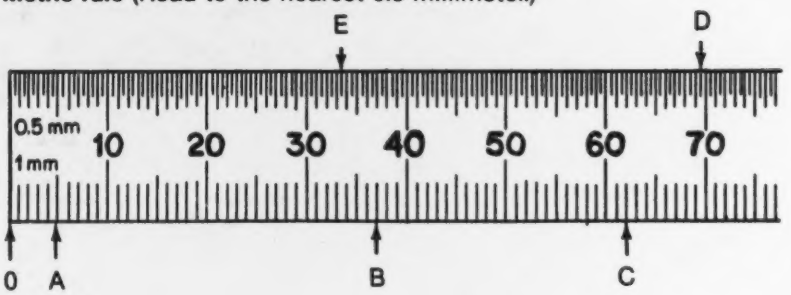
b. 0 to B = _____

c. 0 to C = _____

d. 0 to D = _____

e. 0 to E = _____

Metric rule (Read to the nearest 0.5 millimeter.)



a. 0 to A = _____

b. 0 to B = _____

c. 0 to C = _____

d. 0 to D = _____

e. 0 to E = _____

OBJECTIVE 21

Match the following terms associated with circles to their correct definitions. Write the correct numbers in the blanks.

_____a. Length of a line segment from center of circle to a point on circle

_____b. Closed curved line whose points are all equally distant from the center

_____c. Distance around outside of circle

_____d. 1/60 of a minute

_____e. 1/60 of a degree

_____f. Length of a line segment through center of circle with its ends on circle; divides circle into two equal parts (halves)

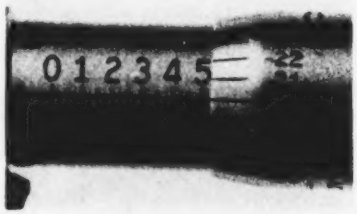
_____g. 1/360 of the circle's circumference

1. Circle
2. Diameter
3. Radius
4. Circumference
5. Degree
6. Minute
7. Second

OBJECTIVE 22

Read the following standard and metric micrometers.

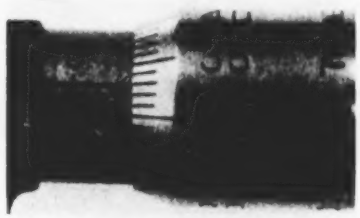
Standard



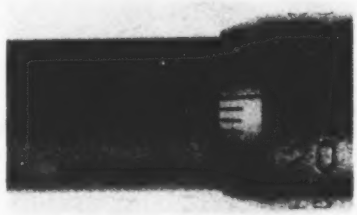
a. _____

b. _____

Metric



c. _____

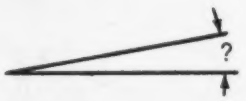


d. _____

OBJECTIVE 25

Choose the closest estimated number of degrees for each of the angles illustrated below. Write the correct numbers on the blanks.

_____a.



1. 80°
2. 40°
3. 10°
4. 20°

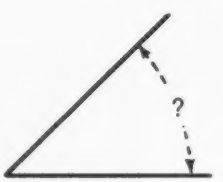
_____b.

1. 175°
2. 275°
3. 80°
4. 280°

_____c.

1. 60°
2. 70°
3. 80°
4. 90°

_____d.



1. 35°
2. 45°
3. 65°
4. 85°

_____e.

1. 5°
2. 10°
3. 15°
4. 20°

_____f.

1. 150°
2. 270°
3. 100°
4. 150°

NOTE: Turn in your test to your instructor, who will grade the test and determine if additional training is needed.

WRITTEN TEST ANSWERS	APPLY RELATED MATH AND MEASURING

OBJECTIVE 1

a. 2
b. 1
c. 3
d. 3
e. 1
f. 2
g. 3
h. 1
i. 2
j. 3
k. 2
l. 2
m. 3

OBJECTIVE 2

a. Units
b. Tens
c. Hundreds
d. Thousands
e. Ten thousands
f. Hundred thousands
g. Millions

OBJECTIVE 3

a. 18,575
b. 7337
c. 313
d. 2020
e. 19,283,117

OBJECTIVE 4

a. 867
b. 1942
c. 119
d. 301
e. 49,931

OBJECTIVE 5

a. 63
b. 72
c. 15,931
d. 107,000
e. 39,204

OBJECTIVE 6

a. 6 R13
b. 12
c. 118 R42
d. 676 R706

OBJECTIVE 7

a. I
b. P
c. P
d. P
e. I
f. M
g. I
h. M
i. P
j. I

OBJECTIVE 8

a. $^{2}/_{3}$
b. $^{1}/_{5}$
c. $^{1}/_{4}$
d. $2\ ^{1}/_{2}$
e. 9
f. $1\ ^{1}/_{2}$
g. $^{1}/_{8}$
h. 12
i. $^{1}/_{6}$

OBJECTIVE 9

a. $^{35}/_{8}$
b. $^{53}/_{6}$
c. $^{15}/_{2}$
d. $^{149}/_{16}$
e. $^{23}/_{4}$

a. 2
b. 1
c. $1\ ^{2}/_{3}$
d. $2\ ^{1}/_{32}$
e. $4\ ^{1}/_{8}$

OBJECTIVE 10

a. 5/8
b. 1 7/8
c. 5/8
d. 10 13/16
e. 7 11/32

OBJECTIVE 11

a. 6 1/4
b. 1 3/8
c. 3 3/32
d. 1 5/8
e. 1/8

OBJECTIVE 12

a. Ten thousandths
b. Thousandths
c. Hundredths
d. Tenths

OBJECTIVE 13

a. 81.505
b. 66.35
c. 205.2908
d. 36.7716
e. $312,998.52

OBJECTIVE 14

a. 216.21
b. 3.3
c. .75
d. 1602.89
e. $4581.09

OBJECTIVE 15

a. 2.27332
b. 1.3266
c. 1198.622
d. 7.643237
e. 4911.32

OBJECTIVE 16

a. 75.92
b. 175

OBJECTIVE 17

	Denominations	1¢	5¢	10¢	25¢	50¢	$1	$5	$10	Result
a.	$2.76 out of $5.00	4		2			2			$ 2.24
b.	17¢ out of 50¢	3	1		1					$ .33
c.	$1.29 out of $20.00	1		2		1	3	1	1	$18.71
d.	$6.98 out of $10.00	2					3			$ 3.02
e.	39¢ out of $1.09			2		1				$ .70
f.	81¢ out of $5.00	4	1	1			4			$ 4.19
g.	$4.79 out of $20.00	1		2				1	1	$15.21

OBJECTIVE 18

a. 0.56
b. 0.88
c. 0.25
d. 5.75
e. 9.09
f. 72.30
g. 5.09
h. 1.02
i. 15.83

OBJECTIVE 19

a. One hundredth of a meter
b. One thousandth of a liter
c. One thousand meters
d. One hundred grams
e. One tenth of a meter
f. Ten liters

OBJECTIVE 20

a. $^{15}/_{16}$"
b. $1\ ^{7}/_{8}$"
c. $2\ ^{3}/_{4}$"
d. $3\ ^{5}/_{16}$"
e. $4\ ^{1}/_{2}$"

a. 5 mm
b. 37 mm
c. 62 mm
d. 69.5 mm
e. 33.5 mm

OBJECTIVE 21

a. 3
b. 1
c. 4
d. 7
e. 6
f. 2
g. 5

OBJECTIVE 22

Standard

a. 0.520"
b. 0.949"

Metric

a. 4.33 mm
b. .17.76 mm

OBJECTIVE 25

a. 3
b. 1
c. 4
d. 2
e. 4
f. 1

OBJECTIVE SHEET

UNIT A-5 STUDY AUTOMOTIVE DESIGN

INTRODUCTION

Just as your body is composed of complex systems that must work together smoothly so that the body functions properly, an automobile is composed of complex systems that must work together smoothly so that the vehicle functions properly. And just as all medical personnel (nurses, technicians, and doctors) must have an understanding of all the body systems and how they work together—no matter what their specialty areas—people involved in the automotive industry (specialists, service managers, production workers, and vocational educators) must have an understanding of all vehicle systems and how they work together—no matter what their specialty areas.

UNIT OBJECTIVE

After completing this unit, the student should be able to recognize the purposes of the major systems of a vehicle and perform basic preventive maintenance procedures on vehicles. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit A-4, "Apply Related Math and Measuring."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with automotive design by choosing the correct definition from a list of four choices.
2. Recall major functional areas of a vehicle by listing the functional areas and their purpose(s).

3. Identify major vehicle body styles by writing the correct names for given illustrations.

4. Recall basic components of a piston engine by labeling components shown on an illustration.

5. Explain the operation of a four-stroke-cycle piston engine by describing the sequence of actions that takes place during each of the four strokes.

6. Recall engine classification factors by using correct classification factors to describe engines.

7. Clean an engine. (Job Sheet 1)

8. Recognize purpose(s) of the major systems of a vehicle by choosing the correct purpose(s) from a list of four choices.

9. Apply guidelines for classifying vehicles according to their power-train design by writing the correct names of power-train components for given illustrations. (Assignment Sheet 1)

10. Perform vehicle fluid-level checks. (Job Sheet 2)

11. Clean and service batteries. (Job Sheet 3)

12. Inspect drive belts. (Job Sheet 4)

13. Check tire air pressure. (Job Sheet 5)

14. Perform vehicle safety inspection. (Job Sheet 6)

SUGGESTED ACTIVITIES	STUDY AUTOMOTIVE DESIGN

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Put up posters; charts, and signs, etc., that emphasize automotive design. Have articles, specification guides, mock-ups, and other references about automotive design available for student use.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Read the introduction to the unit (see the objective page), and then list the major systems of a vehicle on the chalkboard. Ask the class to briefly describe the purpose and design of each system. Further explain why it is important that all people involved in the automotive industry have an understanding of all vehicle systems—no matter what their specialty areas may be.

Objective 1 Recognize definitions of terms associated with automotive design

- Point to examples that illustrate terms in the shop and make examples available in the classroom.
- Read to the class the box material included in the objective and discuss the differences among *parts, assemblies,* and *components* and among *install, reinstall,* and *replace*.
- Have students complete Supplement 1, "Automotive Design Crossword Puzzle."

Objective 2 Recall major functional areas of a vehicle and their purpose(s)

Body

- Explain that most automotive body parts and panels are made from thin sheet metal but that plastic and fiberglass are being used more and more for automotive body parts.
- Explain that a car is designed to protect occupants during an accident. The car body is designed to collapse in a special way to absorb shock and protect passengers during a head-on collision, and strong metal beams are built into doors and side panels to protect passengers during a side collision. Ask students to list other safety features built into vehicles.
- Explain that body design must be aerodynamically sound to facilitate fuel economy.
- Discuss Supplement 2, "Major Vehicle-Size Classifications."
- Have students read Student Supplement 3, "Standard Glazing-Material Codes and Terms." Discuss supplement in class.
- Demonstrate the steps for inspecting the windshield and other glazing material, see proper section of Job Sheet 6, "Perform Vehicle Safety Inspection."
- Have students practice inspecting the windshield and other glass, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

Chassis (frame)

- Discuss how the frame supports the engine, wheels, and body.

- Discuss the differences between a conventional chassis design and a unitized-body-and-frame design. Use Transparency 1, "Conventional Chassis Design," and Transparency 2, "Unitized-Body-and-Frame Design," to illustrate your discussion.

Engine

- Explain and define *displacement*, *torque*, *compression ratio*, *engine sizing*, *bore*, *stroke*, *rpm*, and *cubic-inch displacement*. Use Supplement 3, "Engine Measurements," to expand your discussion.

- Discuss the two ways to increase the power of the engine: raising compression and forcing the engine to consume more air.

- Discuss metric sizings for engines of all different kinds. Use Supplement 3, "Engine Measurements," to expand your discussion.

Drivetrain

- Explain how the traditional drivetrain takes rotating power from the engine and transfers it to the drive wheels. Discuss the purpose of each component in the traditional drivetrain, illustrating your discussion with Transparency 3, "Drivetrain." Point out that each component of the drivetrain is interrelated and that if one part breaks down, the entire system breaks down.

- Explain the differences between the design of a drivetrain with a manual transmission and one with an automatic transmission.

- Explain the differences among the designs of the drivetrain of front-, rear-, and four-wheel-drive vehicles.

- Discuss the difference between the terms *power train* and *drivetrain*. Review the note concerning this with this objective in the information sheet.

- Show the film, *Power Train*.

Objective 3 Identify major vehicle body styles

- Discuss the differences in the designs of the various types of body styles; use the drawings included in the information sheet to illustrate your discussion.

Objective 4 Recall basic components of a piston engine

- Explain that there are two major engine designs: the piston engine and the rotary engine. Point out the differences between the designs of the two types.

- Explain that the four-stroke-cycle piston engine is the engine most commonly used in American vehicles. Discuss the purposes of the basic components of the four-stroke-cycle piston engine, using Transparency 4, "Basic Components of a Piston Engine," to illustrate your discussion.

Objective 5 Explain the operation of a four-stroke-cycle piston engine

- Explain the operation of a four-stroke-cycle piston engine using Transparency 5, "Sequence of Actions in the Operation of a Four-Stroke-Cycle Piston Engine."

- Go to the shop and allow students to observe an operating engine while you explain the sequence of actions.

- To provide students practice in describing the sequence of actions, have them take notes on the film(s) or on your explanations. Then hold a class discussion where students will be allowed to correct their notes if necessary and turn their notes into complete descriptions to be evaluated by you.

Objective 6 Recall engine classification factors

- Discuss each classification factor presented; use the artwork included in the information sheet to illustrate your discussion.

- Show students illustrations of different types of engines in service manuals and textbooks. Then have them attempt to classify the engines using the factors you have discussed. Conduct a contest to see which students are able to correctly classify the engines.

- Explain that the written test question will ask the student to use correct classification factors to describe two engines. Allow students to practice these descriptions and discuss in class.

- Demonstrate Job Sheet 1, "Clean an Engine."

- Have students practice Job Sheet 1.

Objective 8 Recognize purpose(s) of the major systems of a vehicle

Starting system

- If someone in your community has an early-model crank-starting vehicle, arrange to have them bring the vehicle to your shop and demonstrate how difficult it was to start vehicles before the starting system was invented.

- Discuss the purposes of the components of the modern starting system; use Transparency 6, "Starting System," or a display of replacement components for the starting system to illustrate your discussion.

- Explain ASE certification requirements concerning the starting system.

Ignition system

- Explain that until the late 1960s or early 1970s most automotive engines used a point-type ignition system. Explain the purposes of the components in this type of system.

- Further explain that computer-controlled distributor-less electronic ignition systems are used on automotive engines today; these systems eliminate friction in the system, which decreases wear.

- Discuss the purposes of the components of the modern electronic ignition system; use Transparency 7, "Ignition System," or a display of replacement components for the ignition system to illustrate your discussion.

- Explain ASE certification requirements concerning the ignition system.

Fuel system

- Explain the purposes of the components of a basic carbureted fuel system; use Transparency 8, "Fuel System," or a display of replacement components for the fuel system to illustrate your discussion.

- Display the components of the fuel-injected-type fuel system. Point out the differences in the design of the carbureted-type system and the fuel-injected-type system.

- Explain ASE certification requirements concerning the fuel system.

Engine lubrication system

- Explain the purposes of the components of an engine lubrication system; use Transparency 9, "Engine Lubrication System," or a display of replacement components for the system to illustrate your discussion.

- Explain ASE certification requirements concerning the engine lubrication system.

- Demonstrate the steps in checking the engine-oil level. See proper section of Job Sheet 2, "Perform Vehicle Fluid-Level Checks."

- Have students practice checking the engine-oil level, recording their findings on Student Supplement 1, "Checksheet for Recording Vehicle Fluid Levels."

Engine cooling system

- Show the audiovisual program *Efficient Cooling System*.

- Explain the purposes of the components of the cooling system, using Transparency 10, "Engine Cooling System," or a display of replacement components for the system to illustrate your discussion.

- Explain ASE certification requirements concerning the engine cooling system.

- Demonstrate the steps in checking coolant level. See the proper section of Job Sheet 2, "Perform Vehicle Fluid-Level Checks."

- Have students practice checking the coolant level, recording their findings on Student Supplement 1, "Checksheet for Recording Vehicle Fluid Levels."

Exhaust system

- Explain the purposes of the components of a single exhaust system, using Transparency 11, "Exhaust System," or a display of replacement components for the system to illustrate your discussion.

- Discuss the differences between the designs of a single exhaust system and a dual exhaust system.

- Explain ASE certification requirements concerning the exhaust system.

- Demonstrate the steps in inspecting the exhaust system. See proper section of Job Sheet 6, "Perform Vehicle Safety Inspection."

- Stress the safety precautions that must be taken when working on the exhaust system.

- Have students practice inspecting the exhaust system, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

Emission-control system

- Explain the importance emission control plays in the quality of life in this country.
- Explain the purposes of the components of the emission-control system, using Transparency 12, "Emission-Control System," or a display of replacement components for the system to illustrate your discussion.
- Explain ASE certification requirements concerning the emission-control system.

Steering system

- Explain the purposes of the components of a linkage-type steering system, using Transparency 13, "Steering System," or a display of replacement components for the system to illustrate your discussion.
- Explain the differences between the design of a linkage-type system and a rack-and-pinion-type system. Display components of a rack-and-pinion system or use Transparency 14, "Steering System (Continued)," to illustrate your discussion.
- Discuss ASE certification requirements concerning the steering system.
- Demonstrate the steps in checking steering-fluid level. See the proper section of Job Sheet 2, "Perform Vehicle Fluid-Level Checks."
- Have students practice checking steering-fluid levels; have them record their findings on Student Supplement 1, "Checksheet for Recording Vehicle Fluid Levels."
- Demonstrate the steps in inspecting the steering system. See the proper section of Job Sheet 6, "Perform Vehicle Safety Inspection."
- Have students practice inspecting the steering system, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

Suspension system

- Discuss the purposes of the components of a coil-spring suspension assembly, using Transparency 15, "Suspension System," or a display of replacement components for the assembly to illustrate your discussion. Point out that without shock absorbers a vehicle would bounce like a ball after hitting a bump, and that without springs the jolt felt by the tires would be passed directly to the passengers.

- Explain that suspensions come in many different forms to meet a variety of motoring requirements. Discuss some of the most common suspension systems. Point out the differences in their designs.

- Discuss ASE certification requirements concerning the suspension system.

- Demonstrate Job Sheet 5, "Check Tire Air Pressure."

- Have students practice Job Sheet 5.

- Demonstrate the steps in inspecting the wheels and tires. See the proper section in Job Sheet 6, "Perform Vehicle Safety Inspection."

- Have students practice inspecting the wheels and tires, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

- Demonstrate the steps in inspecting a vehicle's suspension system. See the proper section in Job Sheet 6.

- Have students practice inspecting the suspension system, recording their findings on Student Supplement 4.

Brake system

- Explain the principles behind brake operation: The braking system stops a vehicle by converting kinetic energy (energy of motion) into heat energy through friction. To give an example of these principles, have students recall trying to stop a bicycle by dragging a foot against the ground. Dragging the foot against the ground transfers kinetic energy into heat energy because of the friction produced between the foot and the ground.

- Discuss how the components of a disc-brake assembly function to produce the friction needed to stop or slow a vehicle. Use Transparency 16, "Brake System," or a display of replacement components for the assembly to illustrate your discussion.

- Explain that there are drum-type brake assemblies as well as the disc-type, and that either type may be manually applied or power assisted. Point out the differences in the designs of the various systems.

- Describe the hazards associated with brake repair and the preventive measures required to ensure safety. Notify students to keep current on OSHA guidelines concerning brake-system repair. Post OSHA guidelines in the classroom.

- Discuss ASE certification requirements concerning the brake system.
- Demonstrate the steps in checking the brake-fluid level. See the proper section in Job Sheet 2, "Perform Vehicle Fluid-Level Checks."
- Have students practice checking the brake-fluid level, recording findings on Student Supplement 1, "Checksheet for Recording Vehicle Fluid Levels."
- Demonstrate the steps in inspecting the brake system. See proper section of Job Sheet 6, "Perform Vehicle Safety Inspection."
- Have students practice inspecting the brake system, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

Charging system

- Discuss the purposes of the components of the charging system, using Transparency 17, "Charging System," or a display of replacement components for the system to illustrate your discussion.
- Demonstrate the principles behind the alternator: Electricity is produced when a magnetic field moves over a coil of wire. Discuss the differences between a generator and an alternator.
- Explain the operation of the voltage regulator.
- Explain the function of the system's drive belt.
- Discuss ASE certification requirements concerning the charging system.
- Demonstrate Job Sheet 4, "Inspect Drive Belts."
- Have students practice Job Sheet 4.

Chassis electrical system

- Discuss the purpose of the components of the chassis electrical system. Explain that the heart of the system is the battery. If electrical units are not operating, students should check the battery first. Further explain that wires for vehicle circuits are grouped together in bundles called *harnesses*. Individual wires are then color coded for identification purposes. Use Transparency 18, "Chassis Electrical System," or a display of replacement components for the system to illustrate your discussion.

- Have students examine and follow the wiring harnesses in a vehicle's engine or trunk.
- Discuss ASE certification requirements concerning the chassis electrical system.
- Demonstrate Job Sheet 3, "Clean and Service Batteries."
- Make sure students know location of eye-wash station, and have students read Supplement 4, "First Aid for Electrolyte Contact with Eyes and Skin," and Supplement 5, "Battery Fact Sheet." Discuss these in class.
- Have students practice Job Sheet 3.
- Demonstrate the steps in checking the windshield-washer-fluid level. See the proper section of Job Sheet 2, "Perform Vehicle Fluid-Level Checks."
- Have students practice checking the windshield-washer-fluid level, recording their findings on Student Supplement 1, "Checksheet for Recording Vehicle Fluid Levels."
- Demonstrate the steps in inspecting the lighting equipment, windshield wipers, and the horn. See proper sections of Job Sheet 6, "Perform Vehicle Safety Inspection."
- Have students practice inspecting the lighting equipment, windshield wipers, and the horn, recording their findings on Student Supplement 4, "Checksheet for Recording Results of Vehicle Safety Inspection."

Heating and air-conditioning system

- Discuss the purposes of the components of the heating system, using Transparency 19, "Heating System," or a display of replacement components for the system to illustrate your discussion.
- Discuss the purposes of the components of the air-conditioning system, using Transparency 20, "Air-Conditioning System," or a display of replacement components for the system to illustrate your discussion.
- Explain that there are various types of heating and air-conditioning systems. Display service manuals to point out designs other than those pictured in the transparencies.
- Explain what is meant by the term *blended air.*

- Discuss the new computer-controlled environmental systems.
- Discuss ASE certification requirements concerning the heating and air-conditioning system.

Computer-control system

- Use Transparency 21, "Computer-Control System," to illustrate the control centers of the system.
- Display an automotive computer unit. Stress that it is not necessary for the automotive technician to become a computer expert—all he or she need be able to do is to determine whether or not the unit is working properly. Demonstrate how this is determined.
- Explain in simple terms how the computer and the electronic components in the system function.
- Discuss ASE certification requirements concerning the computer-control system.

Objective 9 Apply guidelines for classifying vehicles according to their power-train design.

- Review the information concerning engine design in Objectives 2, 4, 5, and 6. Then explain the assignment sheet.
- Have students complete Assignment Sheet 1. Discuss their answers in class.

Unit summary activity

- Introduce students to the computer program "Car Builder for Apple IIc," and have them complete the program, or discuss Activity Sheet 1, "Design a Vehicle," and have students complete. The purpose of completing the Car Builder program or the activity sheet is to provide students with the opportunity to think about automotive design principles. Students will need to apply not only technical knowledge but also consumer wants and needs. Keep this in mind when discussing the activity.

EVALUATION

- Give written test.
- Give practical test, and evaluate test on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Crouse, William H., and Donald L. Anglin. *The Auto Book*, 3rd ed. New York: McGraw-Hill Book Company, 1984.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- *EEC III, EEC IV:* 5-Day Technician Certification Reference Book. Ford Parts and Service Division, Training and Publications Department, Ford Motor Company, April 1985.
- *Introduction to Automotive Mechanics*, "Unit 2: Lubrication, Cooling, and Safety Inspection Services," Student Guide. Tallahassee, Florida: Florida Department of Education, 1986.
- de Kryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Mitchell Information Services, Inc. *Mitchell Automechanics*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- Motor Vehicle Inspection Division, Oklahoma Department of Public Safety. *Official Motor Vehicle Emission and Mechanical Inspection Rules and Regulations Manual*. Oklahoma City: Oklahoma Department of Public Safety, 1985.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals*. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- Turner, David R. *Certified General Automobile Mechanic*. New York: ARCO Publishing Company, Inc., 1973.

STUDENT REFERENCES

Resources to be used as student references

NOTE: The materials listed below were used as resources in preparing certain components that require information and specifications for specific makes and models of vehicles. Copies of these materials may be required by students in completing assignments.

- Motor Vehicle Inspection Division, Oklahoma Department of Public Safety. *Official Motor Vehicle Emission and Mechanical Inspection Rules and Regulations Manual*. Oklahoma City: Oklahoma Department of Public Safety, 1985.

Media

NOTE: The first three items are available to Oklahoma teachers on a free-loan basis. Oklahoma teachers may order these programs from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Out-of-state teachers must order from the addresses listed.

- *Power Train*. Color, 13 minutes, 1968. Filmfair Communications, 10900 Ventura Blvd., Box 1728, Studio City, California 91604. This cartoon-style film explains the basic gears, the transmission, the clutch, the universal joint, the drive shaft, and the differential of the power-train system.

- *Tire Wise*. Color, 15 minutes, 1976. Aims Instructional Media, 626 Justin Avenue, Glendale, California 91201. This film shows how to get maximum tire mileage and discusses tire safety and the things you should know when you buy a set of tires.

- *Efficient Cooling System*. Color, 14 minutes, 1974. Deere & Company, John Deere, Moling, Illinois 61265. This film explains the function and maintenance of engine cooling systems.

- *Introduction to Automotive Service*, "Study Automotive Design—Clean and Service Battery." Color, 1987. Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074. This VHS videotape presents the steps in cleaning and servicing a battery.

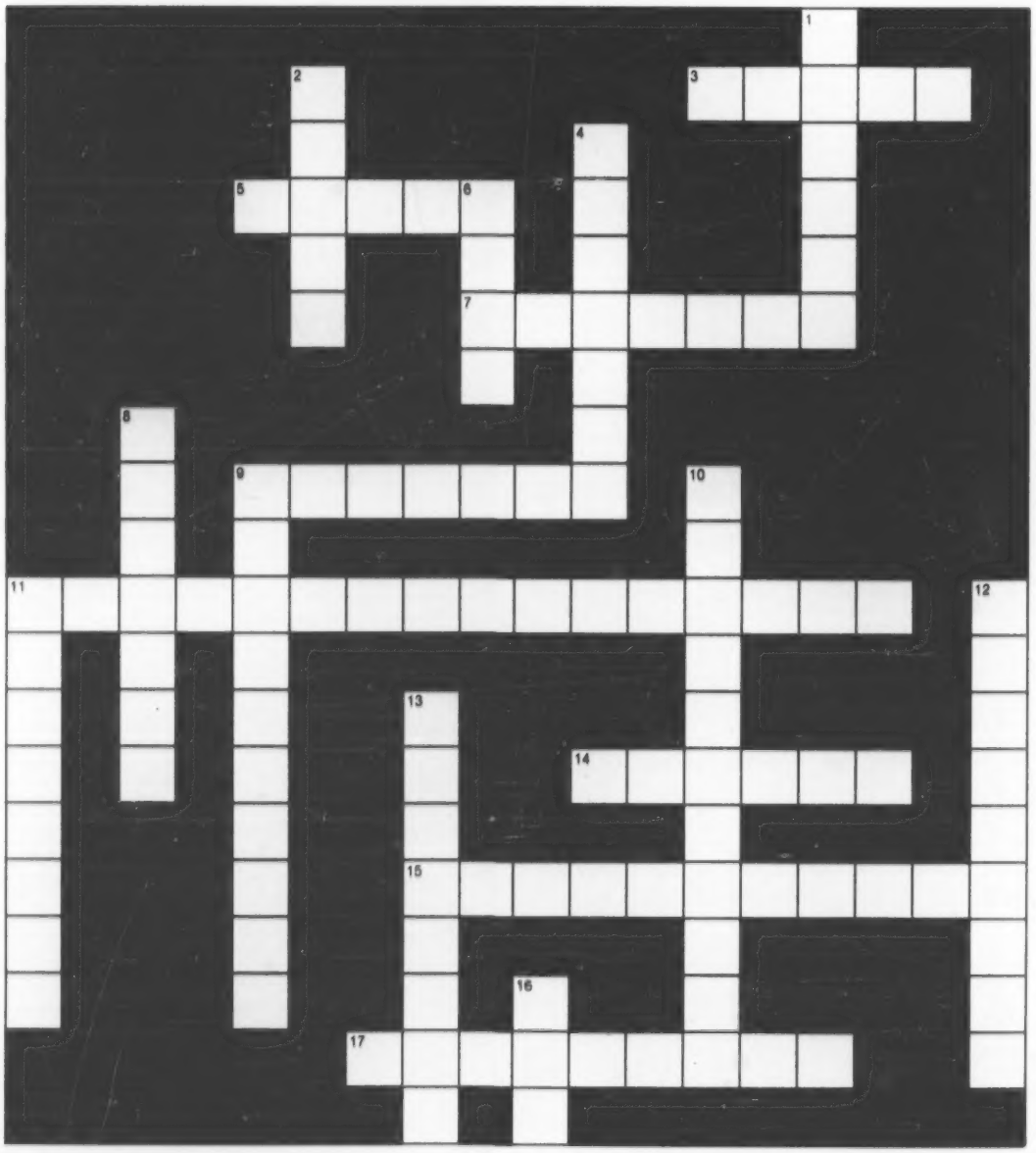
- *Car Builder for Apple IIc*. Weekly Reader Family Software, Career Aids, 2417 Norhoff Street, Chatsworth California 91311; phone 818-341-8200. This software is designed to allow students to apply design principles in creating an automobile design.

Print media

- Transparencies and competency profiles

  NOTE: Transparencies and competency profiles for this book are availble from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

INSTRUCTOR'S SUPPLEMENTS	STUDY AUTOMOTIVE DESIGN
SUPPLEMENT 1	Automotive Design Crossword Puzzle



Clues

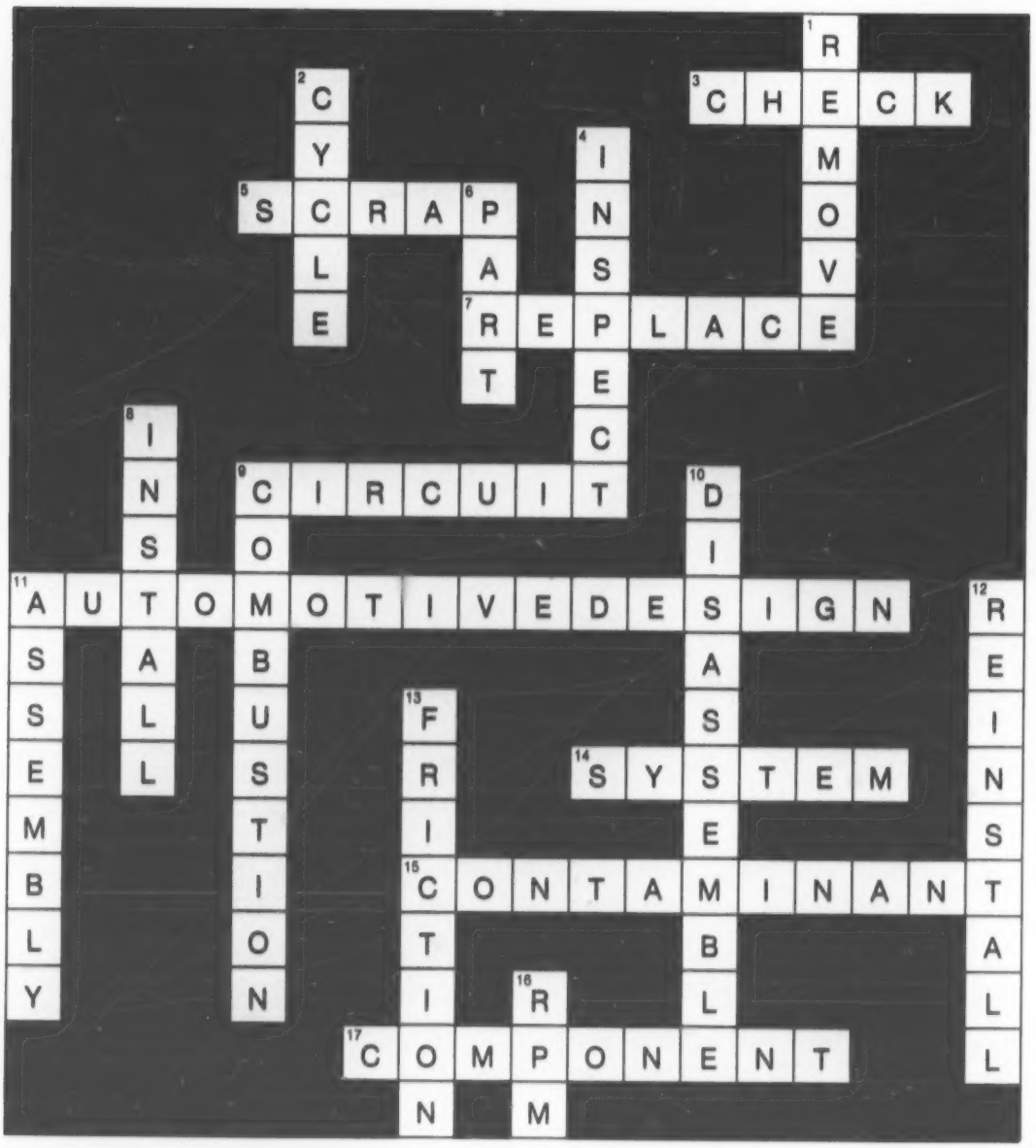
Across

3. To determine whether a substance or object is present and meets specifications
5. Graveyard for dead cars, _____ heap
7. To secure a replacement part, assembly, or component in its proper location
9. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point
11. Plan of the shape of and the mateirals to be used for elements of a vehicle
14. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
15. Undesirable element
17. Member of a system designed to perform a specific but limited function within a system

Down

1. To take a part, assembly, or component from its location
2. Event or series of events that is repeated
4. To examine a part, assembly, or component for wear, damage, size, or shape
6. Element of an assembly or component; member that is not normally useful by itself and cannot be disassembled further
8. To secure a previously removed or a replacement part, assembly, or component, or to add a completely new assembly or component
9. Process of burning
10. To take apart an assembly, component, or system
11. Two or more parts that function together in a component or system
12. To secure a previously removed part, assembly, or component in its proper location
13. Resistance to motion between two parts in contact
16. Revolutions per minute (abbr.)

Answers


1 R
2 C
3 CHECK
Y
4 I
M
5 SCRA
6 P
N
O
L
A
S
V
E
7 REPLACE
T
E
C
8 I
N
9 CIRCUIT
10 D
S
O
I
11 AUTOMOTIVEDESIGN
12 R
S
A
B
A
E
S
L
U
13 F
S
I
E
L
S
R
14 SYSTEM
N
E
S
M
T
I
B
I
15 CONTAMINANT
S
O
T
B
A
Y
N
I
16 R
L
L
17 COMPONENT
L
N
M

INSTRUCTOR'S SUPPLEMENTS	STUDY AUTOMOTIVE DESIGN

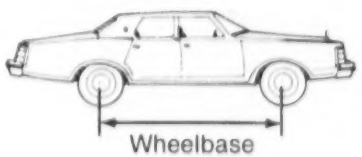
SUPPLEMENT 2

Major Vehicle-Size Classifications

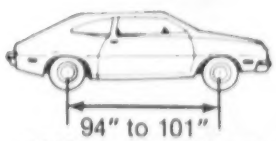
Automobiles are classed according to the size of their wheelbases (see Figure 1-a). For 1987 automobiles, the following size classifications were used; however, consumer demand and economic conditions do cause the industry to change vehicle sizes from year to year.

FIGURE 1

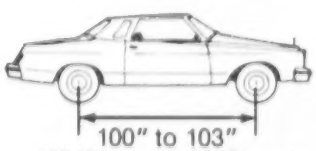
(a) **Wheelbase measurement**



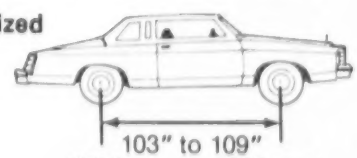
(b) **Subcompact automobile**



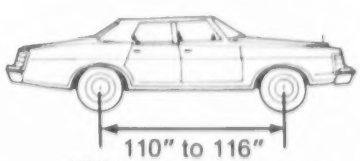
(c) **Compact automobile**



(d) **Intermediate-sized automobile**



(e) **Full-sized automobile**



- **Subcompact** (Figure 1-b). The smallest automobiles, subcompacts, have wheelbases ranging from 94 to 101 inches (2388 mm to 2565 mm). Models included in the subcompact class are the AMC Alliance, Chevrolet Cavalier, Dodge Omni, Ford Escort, Plymouth Horizon, and Pontiac Sunbird.
- **Compact** (Figure 1-c). Slightly larger automobiles, the compacts, have wheelbases ranging from 100 to 103 inches (2540 mm to 2616 mm). Models included in the compact class include the Dodge Aries, Ford Tempo, Mercury Topaz, and Plymouth Reliant.
- **Intermediate** (Figure 1-d). Intermediate-sized models, including the Buick Century, Chevrolet Celebrity, and Dodge Lancer, have wheelbases ranging from 103 to 109 inches (2616 mm to 2769 mm).
- **Full size** (Figure 1-e). In the full-sized class, automobiles have wheelbases ranging from 110 to 116 inches (2794 mm to 2946 mm) and include models such as the Buick LeSabre, Chevrolet Caprice, Ford LTD Crown Victoria, and Oldsmobile Delta 88.

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SUPPLEMENT 3

Engine Measurements

When referring to engine size, the quantity that is measured is displacement—not the physical dimensions of an engine. This means that a *big* engine is one with a great deal of displacement and a *smaller* engine is one with less displacement. *Displacement* is the volume through which a piston moves from BDC to TDC on a stroke. *Total engine displacement* is the sum of all the individual cylinder displacements during one revolution of the crankshaft.

Two types of units of measure are used in expressing engine size: U. S. customary units (U. S. standard units) and metric units (International System units [SI]). Cylinder volume in U. S. customary units is expressed in cubic inches (1 cubic inch is the volume contained in a cube that measures 1 inch on each side).

Cylinder volume in metric units is expressed in cubic centimeters, which is converted into liters. A cubic centimeter is the volume contained in a cube that measures 1 centimeter on each side, and 1000 cubic centimeters equal 1 liter.

The following table shows the formulas used for converting liters, cubic inches, and cubic centimeters.

Multiply by	to convert	to
.016	Cubic inches	Liters
61.020	Liters	Cubic inches
16.390	Cubic inches	Cubic centimeters
.061	Cubic centimeters	Cubic inches

Today, all foreign and domestic automobile engine measurements are expressed in liters. However, most U.S. auto makers still provide the cubic-inch equivalent in general engine specifications. The table below shows various engine sizes given in both liters and cubic inches.

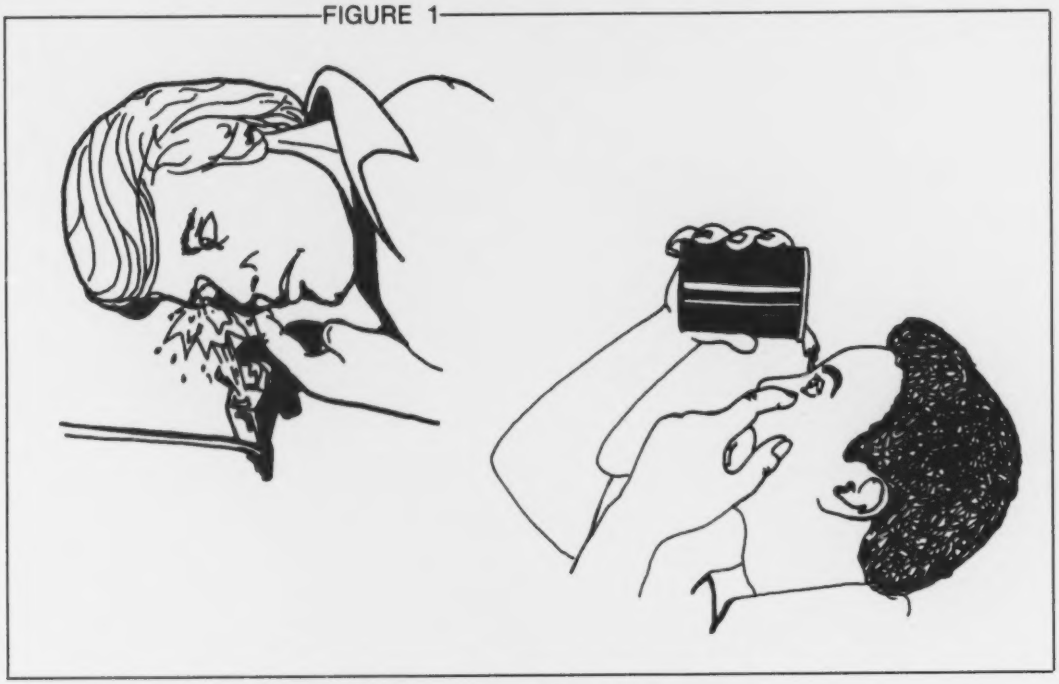
Make and model	Number of cylinders	Engine size	
		cubic inches	liters
1986 Chrysler			
Front-wheel drive	Four	97	1.60
	Four	135	2.20
	Four	153	2.50
Rear-wheel drive	Eight	318	5.20
1986 Ford			
Compact and intermediate	Four	140	2.30
	Six	232	3.80
	Eight	302	5.00
1986 General Motors	Four	110	1.80
	Four	151	2.50
	Six	231	3.80
	Eight	250	4.10
	Eight	307	5.00
1983-1986 American Motors	Six	258	4.23

SUPPLEMENT 4

First Aid for Electrolyte Contact with Eyes or Skin

- Eye contact
  1. Immediately flush eyes with cool running water for at least 15 minutes. (See Figure 1 below.)
  2. Seek medical attention immediately.
  3. *If* medical assistance is **not** immediately available, neutralize acid with baking-soda-and-water solution (2 tablespoons baking soda in 2 cups of water), and then seek medical attention as quickly as possible.

FIGURE 1



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- Skin contact
  1. Remove clothing from affected area if necessary.
  2. Flush skin with cool running water for at least 5 minutes.
  3. Pour a solution of baking soda and water (2 tablespoons baking soda in 2 cups water) over skin until electrolyte has been neutralized.
  4. Seek medical attention if blistering, burning, or peeling occurs.

SUPPLEMENT 5 — Battery Fact Sheet

FACT SHEET
U.S. CONSUMER PRODUCT SAFETY COMMISSION WASHINGTON, D.C. 20207

NO. 82: BATTERIES

The U.S. Consumer Product Safety Commission estimates that more than 10,000 persons receive hospital emergency-room treatment each year for injuries associated with wet-cell batteries and dry-cell batteries. The typical injury is a chemical burn caused by contact with acid in the battery.

WET-CELL BATTERIES

The most common storage battery is found in the automobile. Car batteries contain a solution of sulfuric acid and water that, when activated, produces explosive gases which are easily ignited.

The explosive gases and the acid can contribute to severe injury, as illustrated in the following cases taken from CPSC investigation files:

SANDRA WAS ATTEMPTING TO JUMP START HER CAR. AS SHE WAS CONNECTING THE CABLES TO THE DEAD BATTERY, A SPARK WAS PRODUCED WHICH CAUSED THE BATTERY TO EXPLODE. THE BATTERY CAPS FLEW OFF AND BATTERY ACID SPLASHED INTO HER EYES, CAUSING CHEMICAL BURNS.

HENRY WAS TRYING TO JUMP START HIS FRIEND'S CAR. WHEN CONNECTING THE JUMPER CABLES, HE UNKNOWINGLY CROSSED THE POLARITY BY CONNECTING ONE CABLE TO THE POSITIVE TERMINAL ON HIS BATTERY AND THE OTHER END TO THE NEGATIVE TERMINAL ON THE DEAD BATTERY. AS HE CONNECTED THE OTHER CABLE, NEGATIVE TO POSITIVE, HIS BATTERY EXPLODED. HE CUT HIS HAND AND SUFFERED A CHEMICAL BURN TO HIS EYE FROM THE BATTERY ACID.

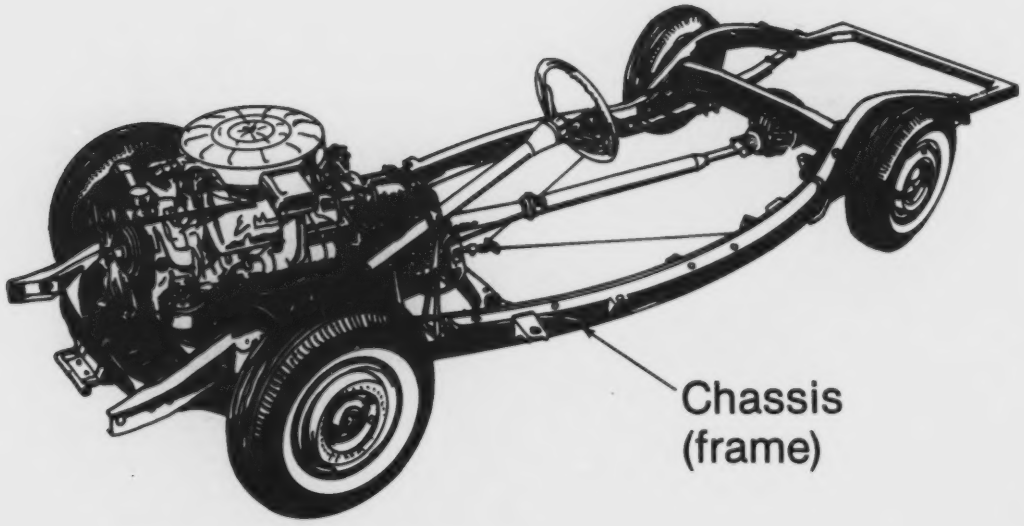
JOHN TOOK THE CAPS OFF HIS BATTERY TO CHECK THE WATER LEVEL. HE LIT A CIGARETTE LIGHTER FOR MORE LIGHT AND AS HE HELD THE LIGHTER NEAR THE HOLES, THE GASES FROM THE BATTERY IGNITED, CAUSING AN EXPLOSION WHICH SPLASHED BATTERY ACID INTO HIS EYES.

KELLY WAS CLEANING THE ACCUMULATED CORROSION FROM THE TERMINALS ON HER CAR BATTERY WITH A SODA SOLUTION AND A CLEANING CLOTH. AFTER SHE FINISHED, SHE INADVERTENTLY RUBBED ONE EYE BEFORE WASHING HER HANDS. THE ACID IN THE CORROSION CAUSED A CHEMICAL BURN IN HER EYE.

These case histories illustrate major accident patterns associated with wet-cell batteries. Most accidents occur when batteries are jumped, recharged, or otherwise serviced.

To report a product hazard or a product-related injury, write to the U.S. Consumer Product Safety Commission, Washington, D.C. 20207. In the continental United States, call the toll-free safety hot line 800-638-2666. Maryland residents only, call 800-492-2937.

Conventional Chassis Design



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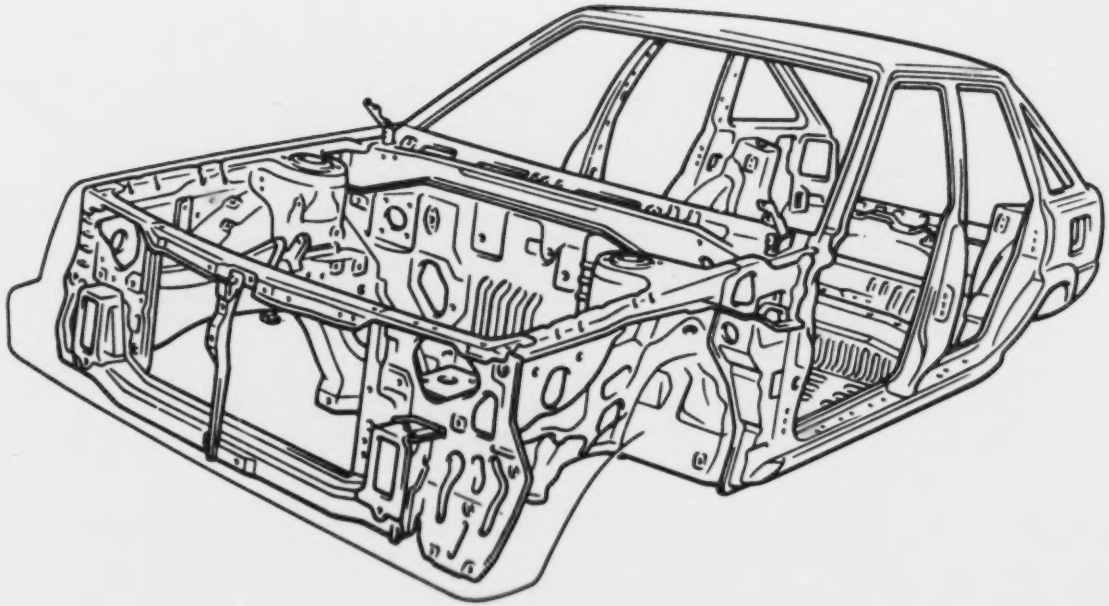
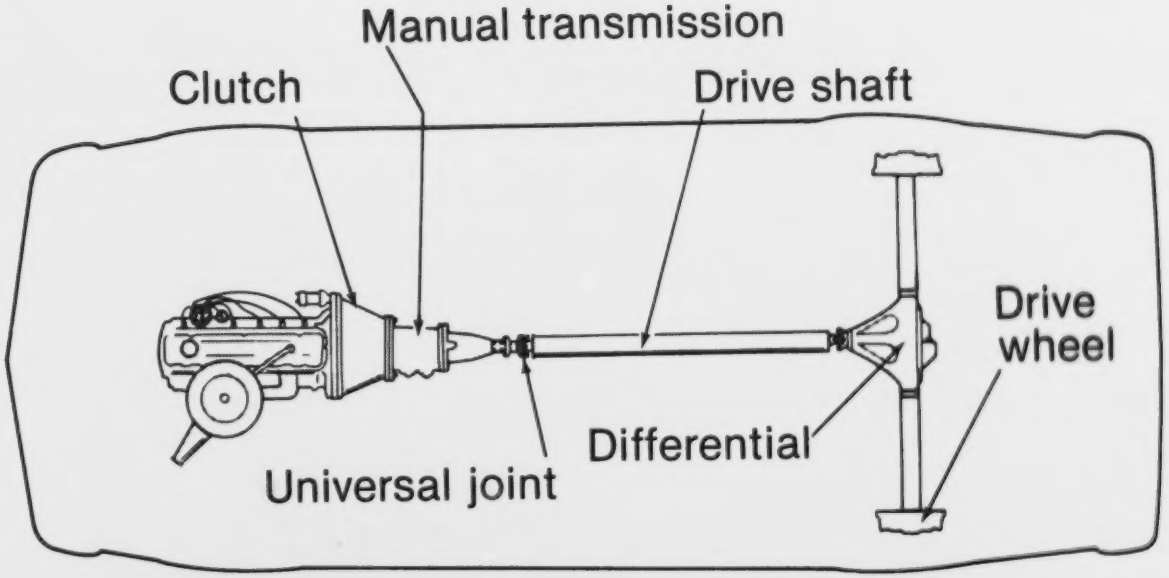
Unitized-Body-and-Frame Design



Drivetrain



Traditional drivetrain with manual transmission

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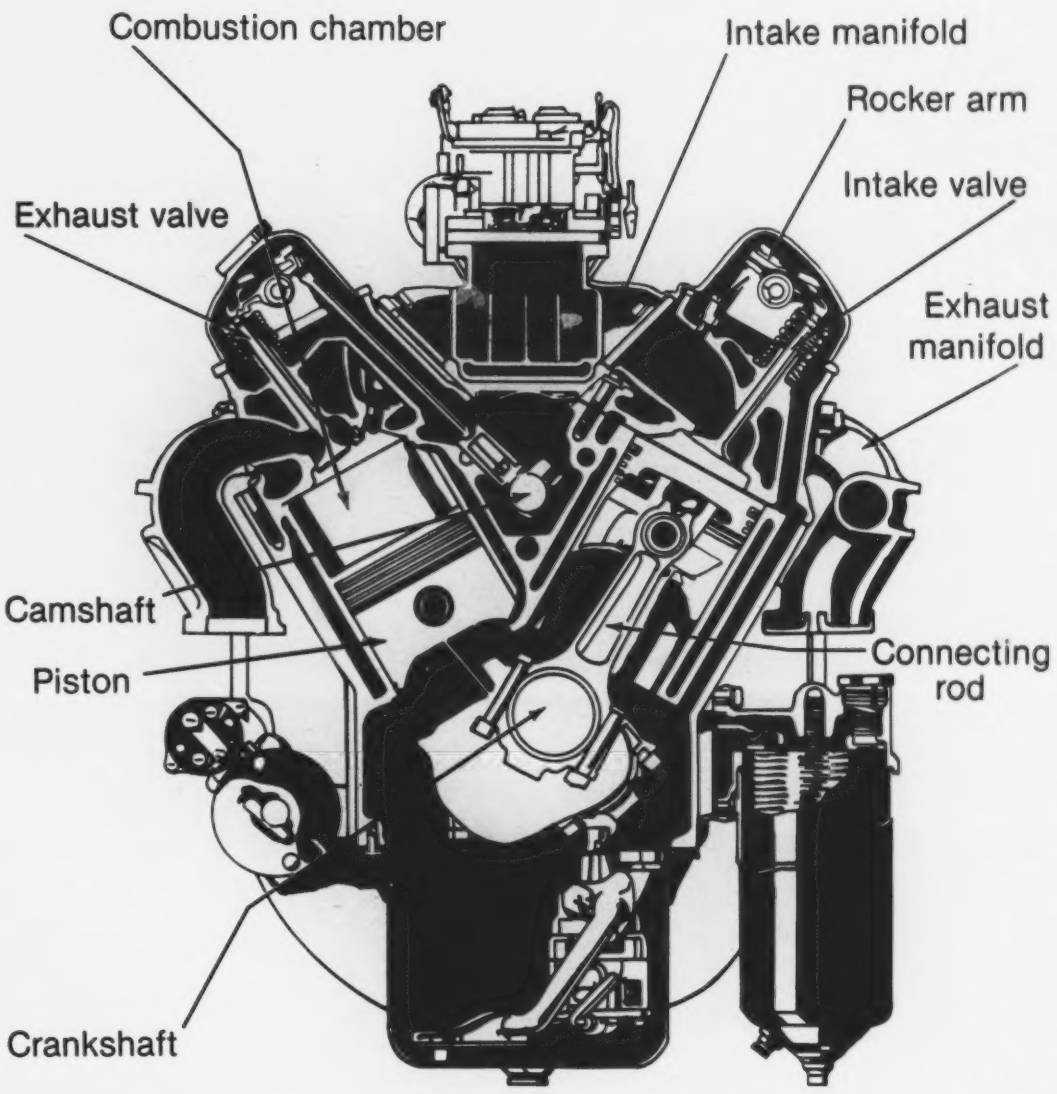
Basic Components of a Piston Engine



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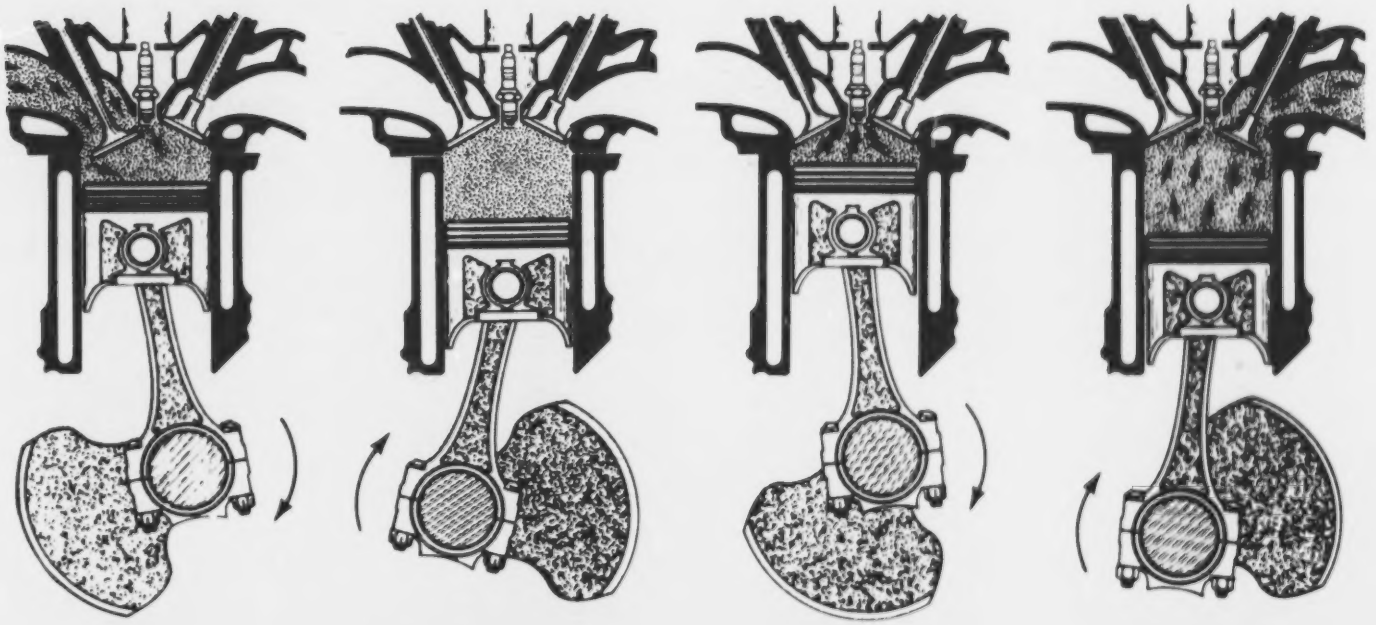
Sequence of Actions in the Operation of a Four-Stroke-Cycle Piston Engine



Intake Compression Power Exhaust

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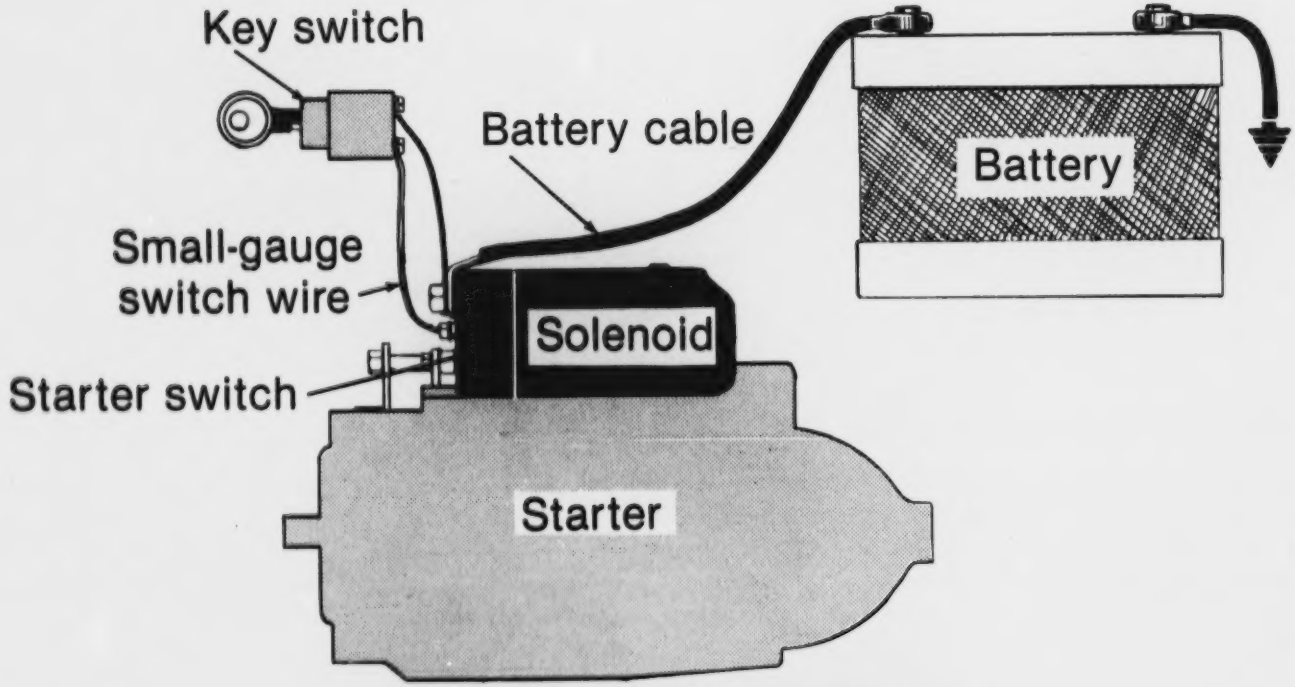
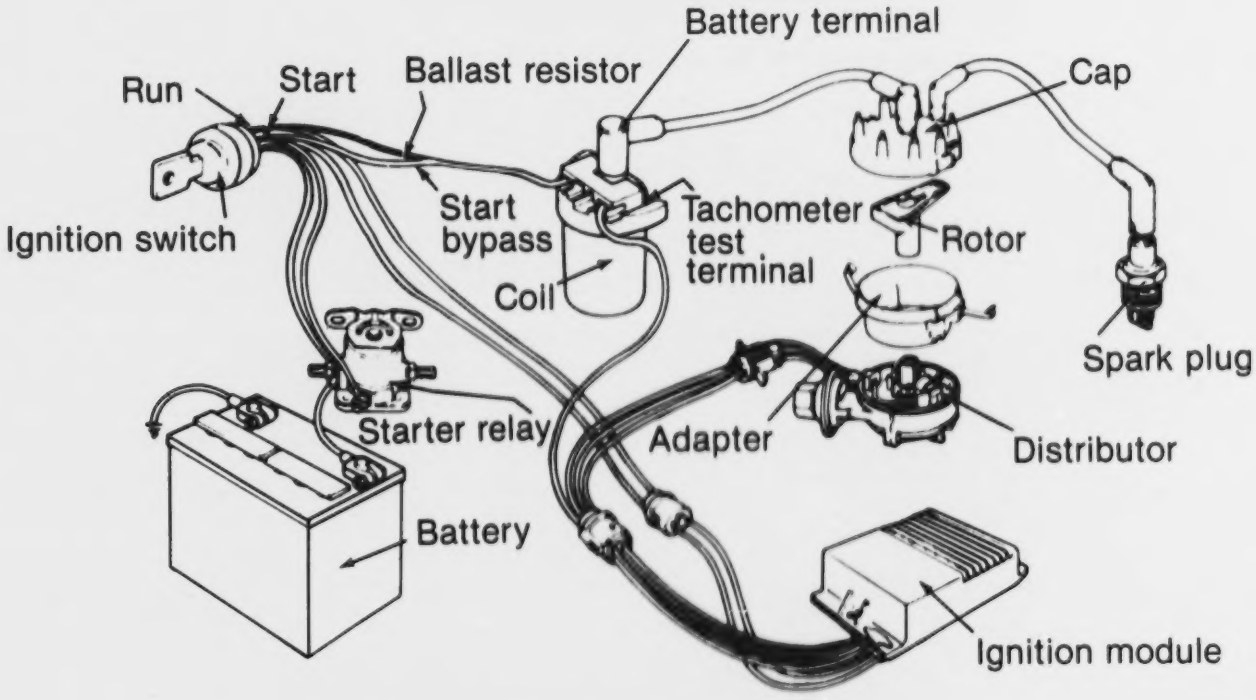
Starting System



Components of a modern starting system

Ignition System



Electronic ignition system

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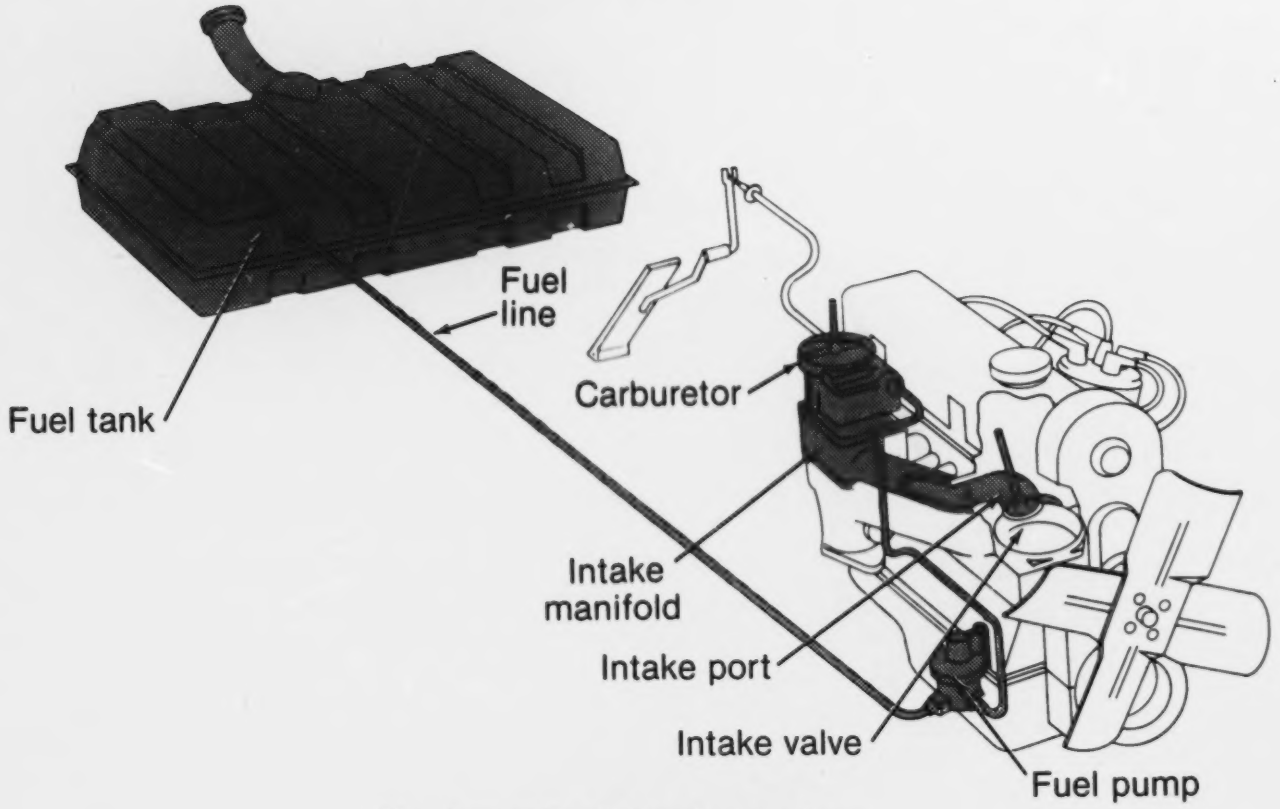
Fuel System



Carbureted fuel system

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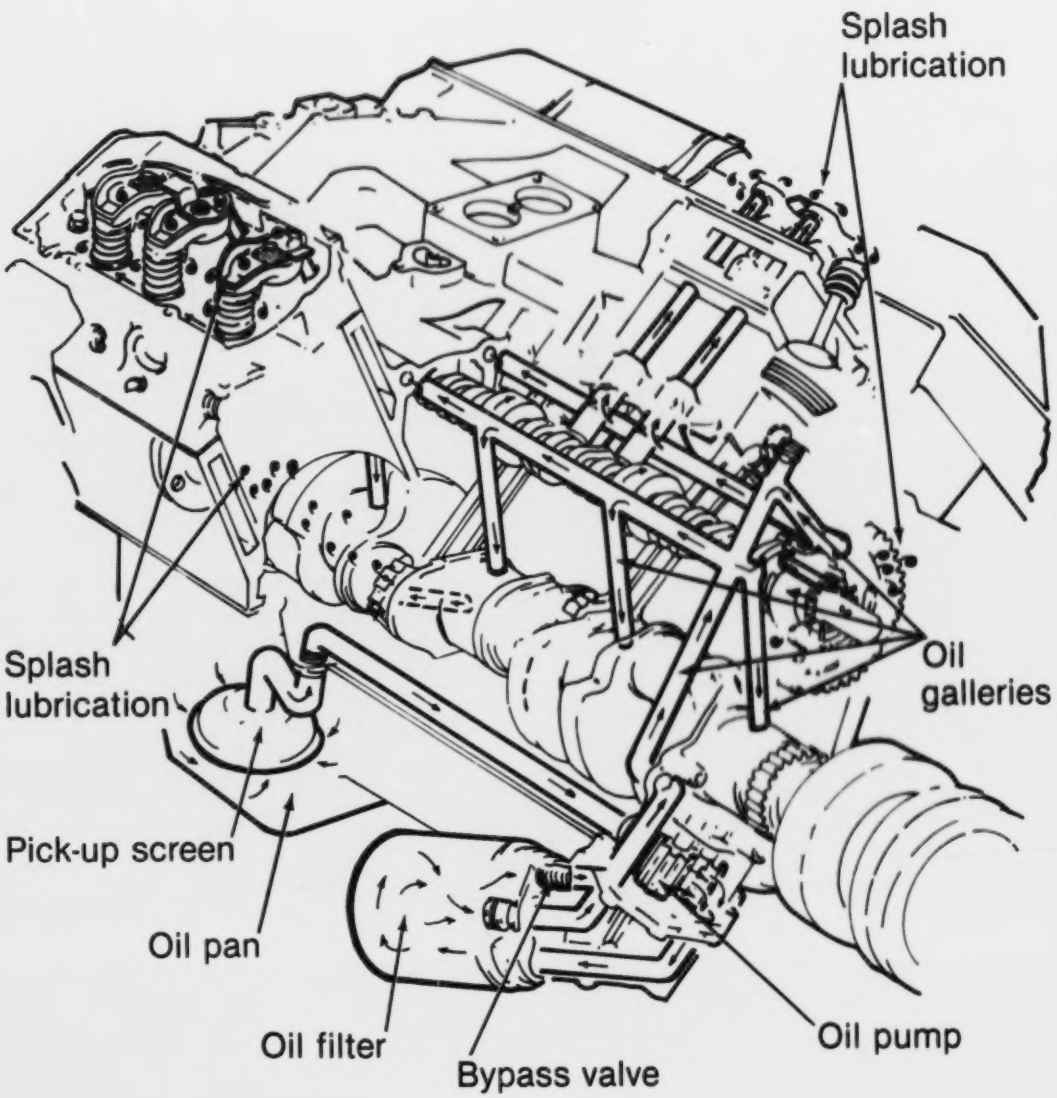
Engine Lubrication System



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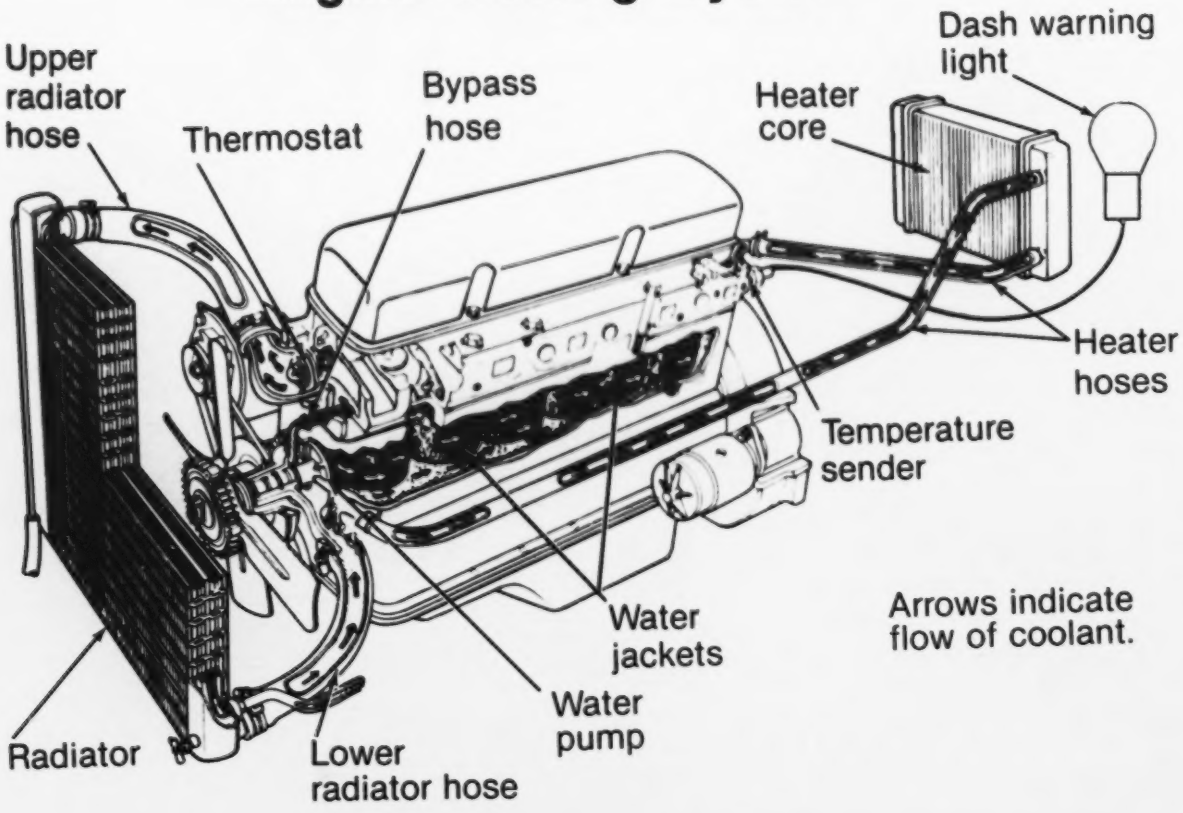
Engine Cooling System



Liquid-type cooling system

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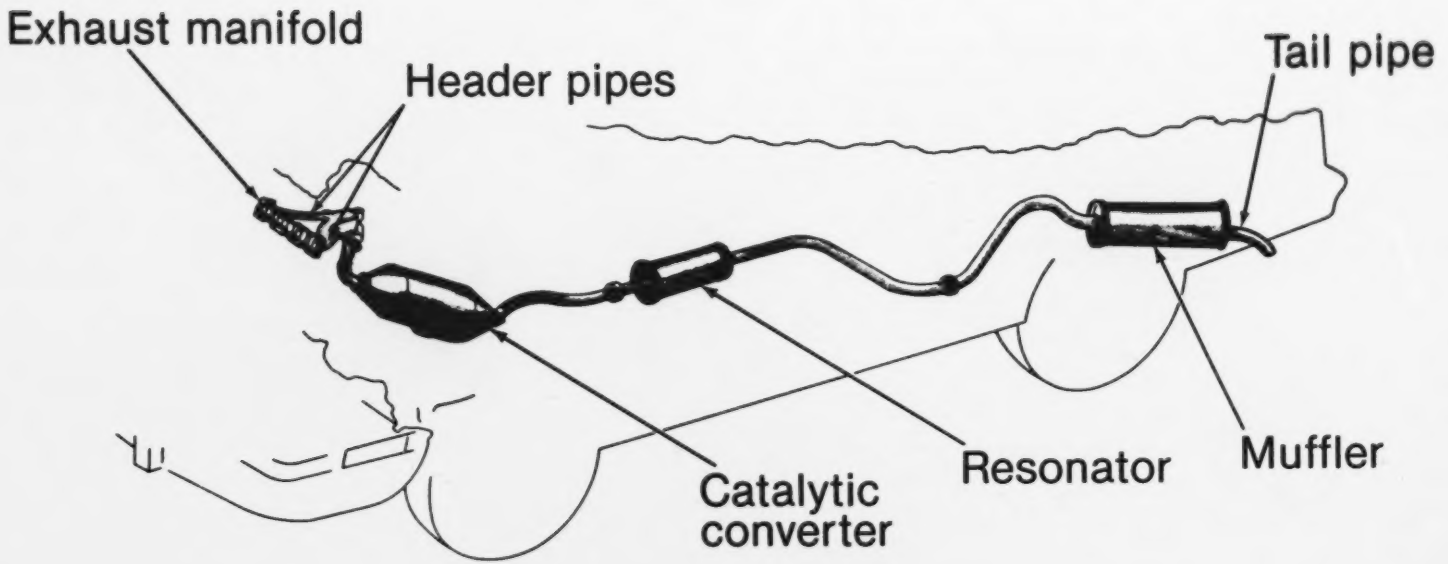
Exhaust System



Single exhaust system

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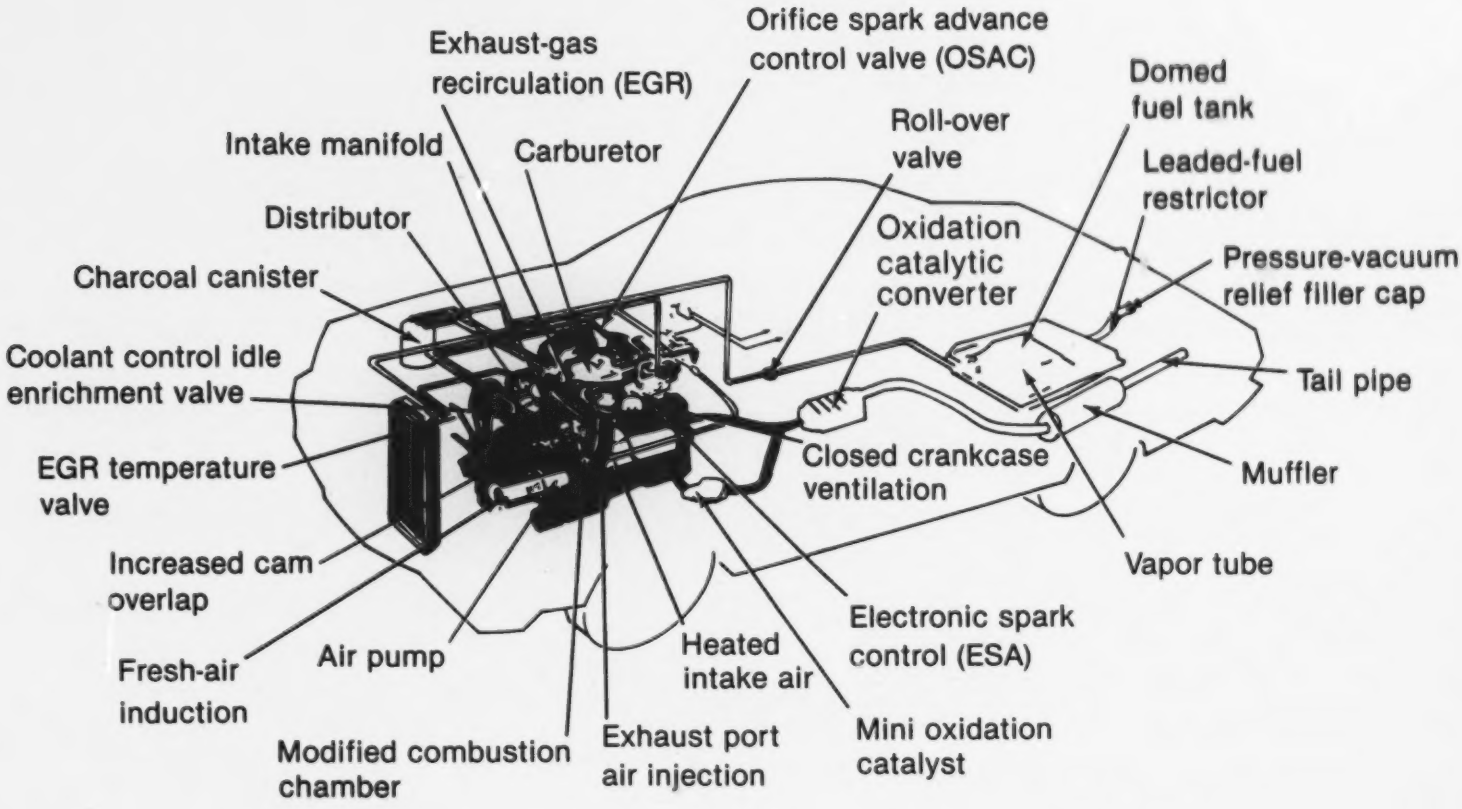
Emission-Control System



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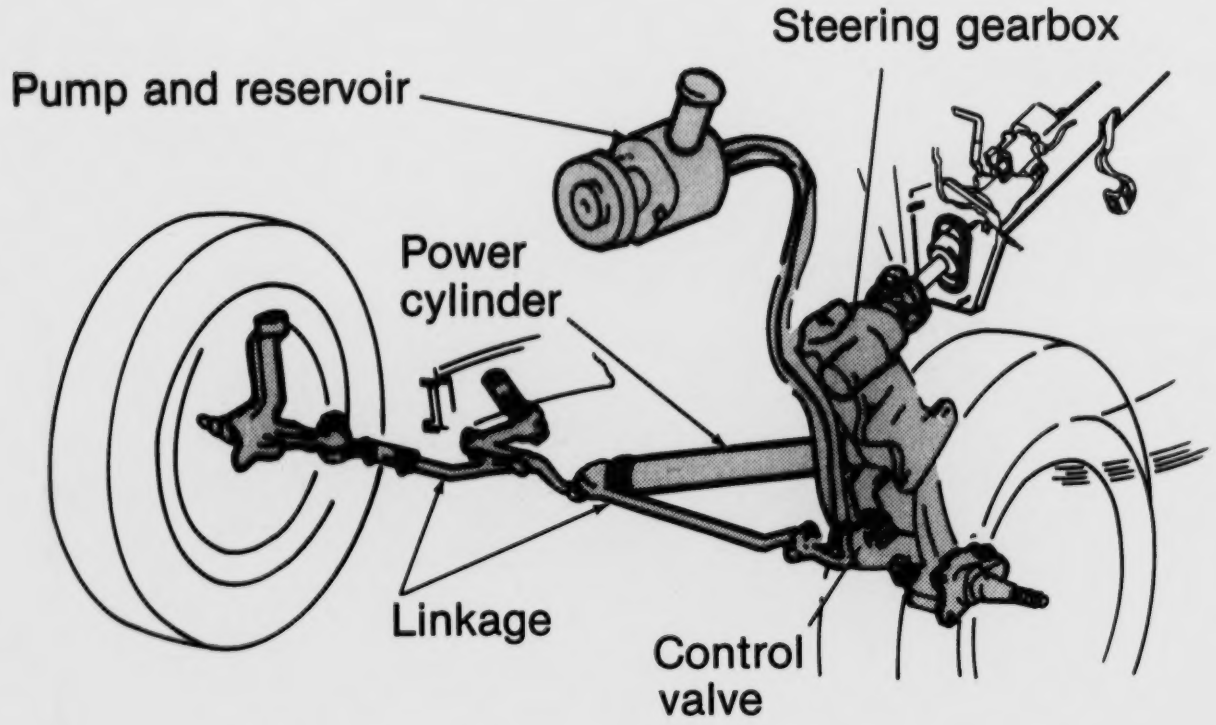
Steering System



Linkage-type system

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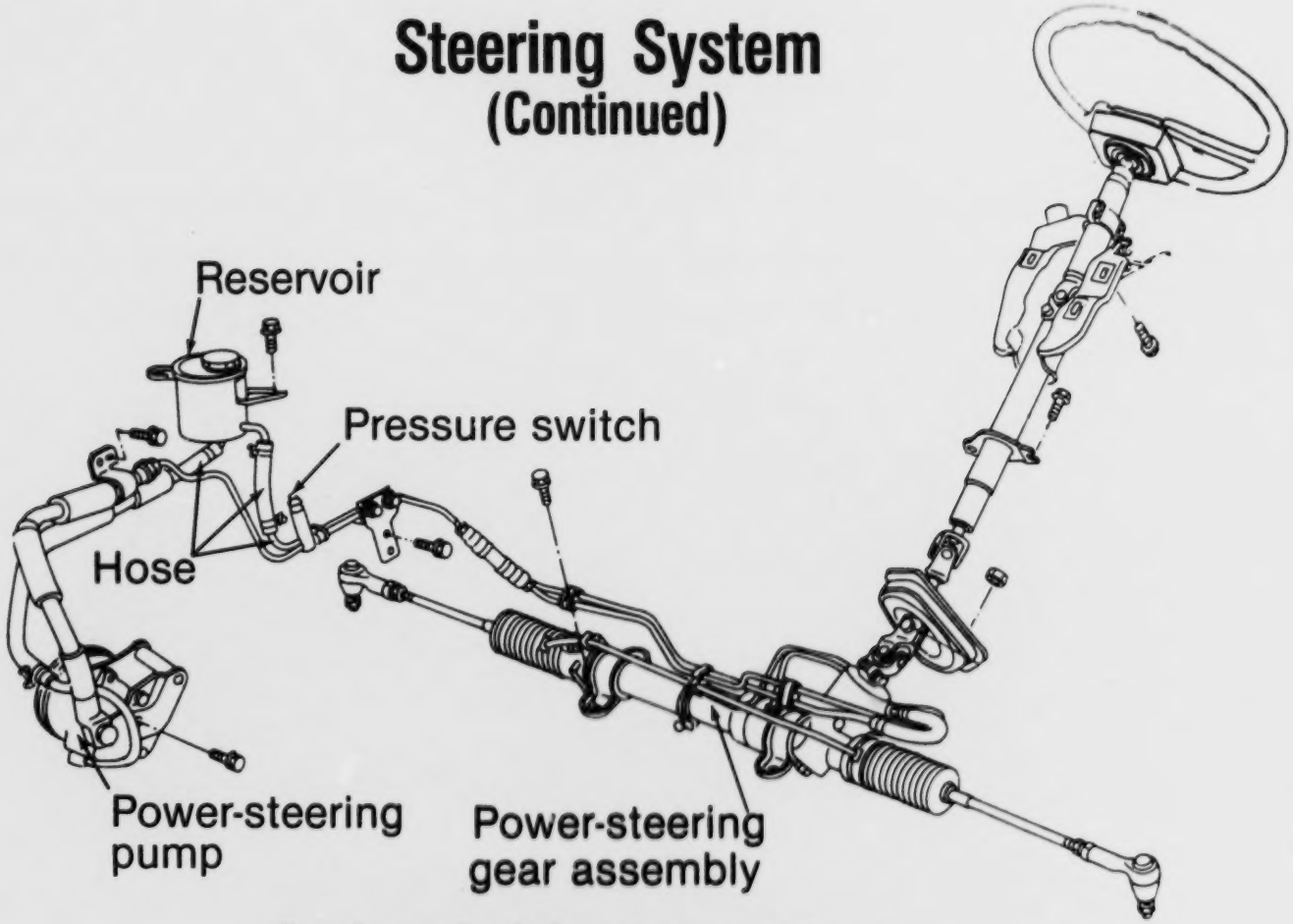
Steering System
(Continued)



Rack-and-pinion-type system

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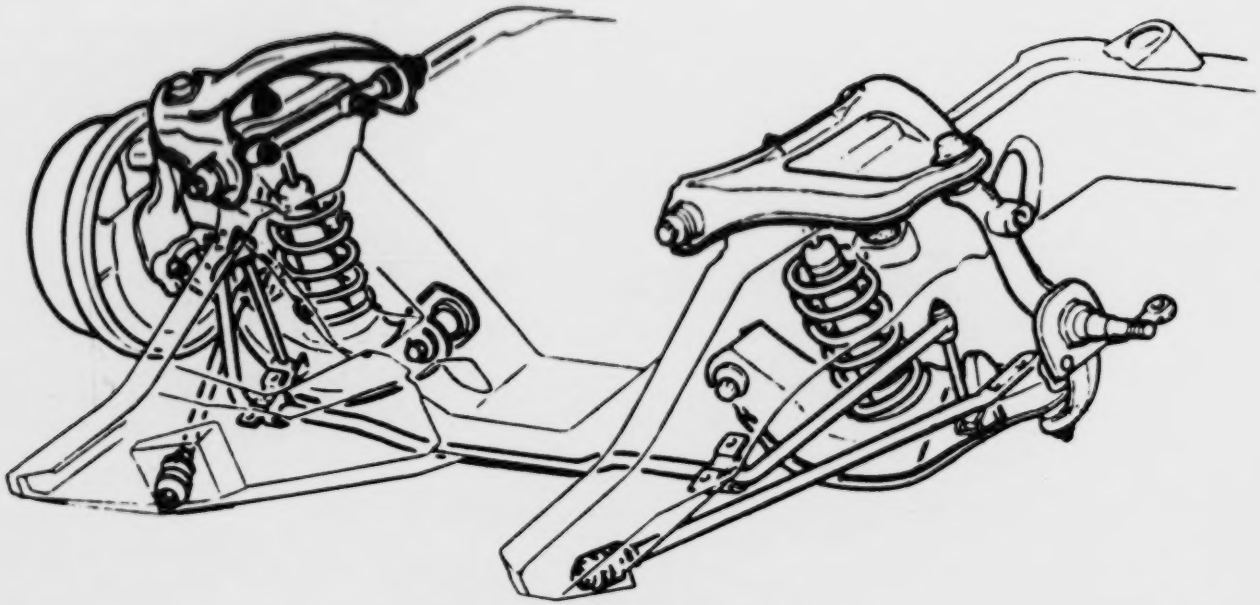
Suspension System



Coil-spring assembly

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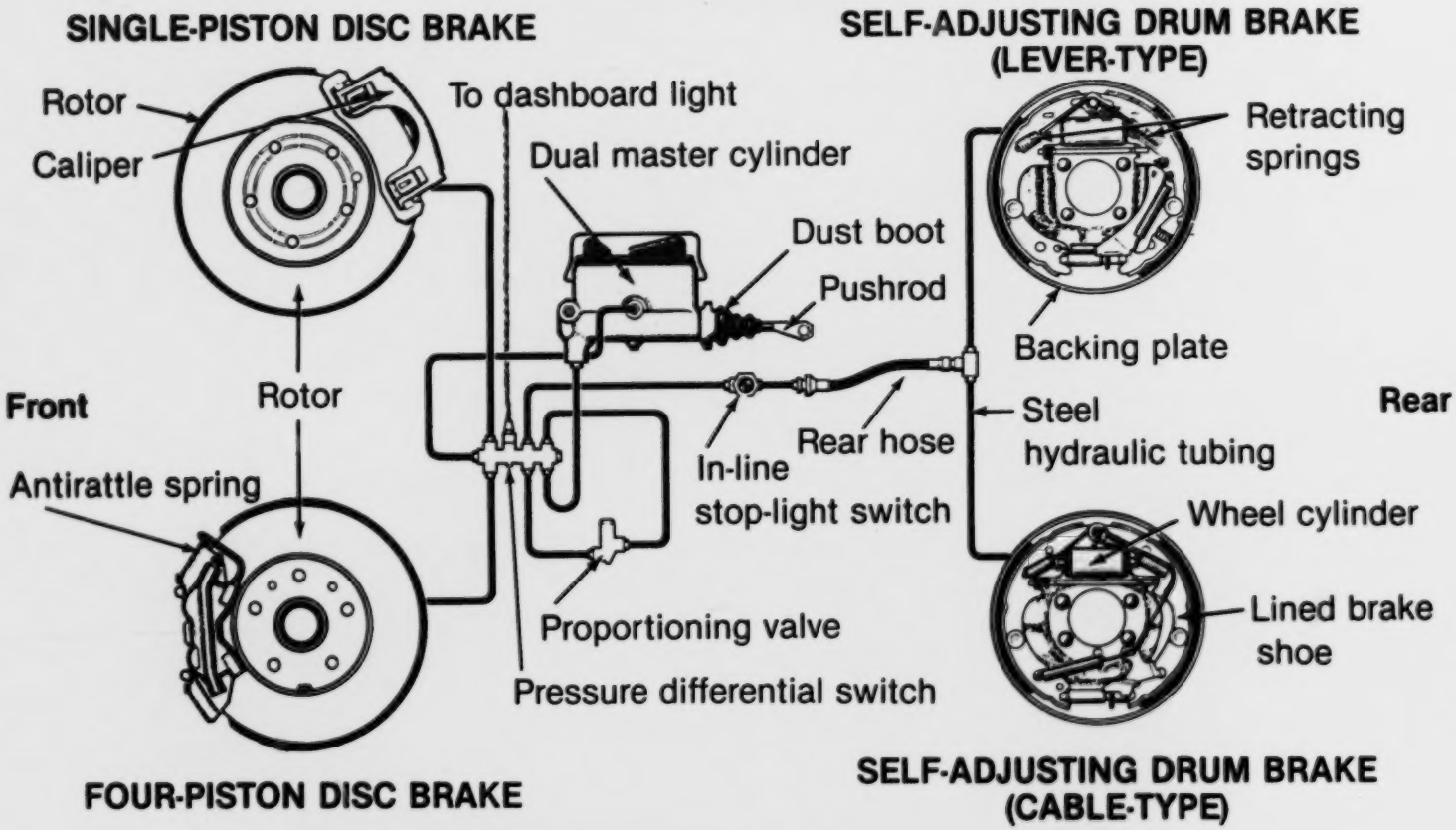
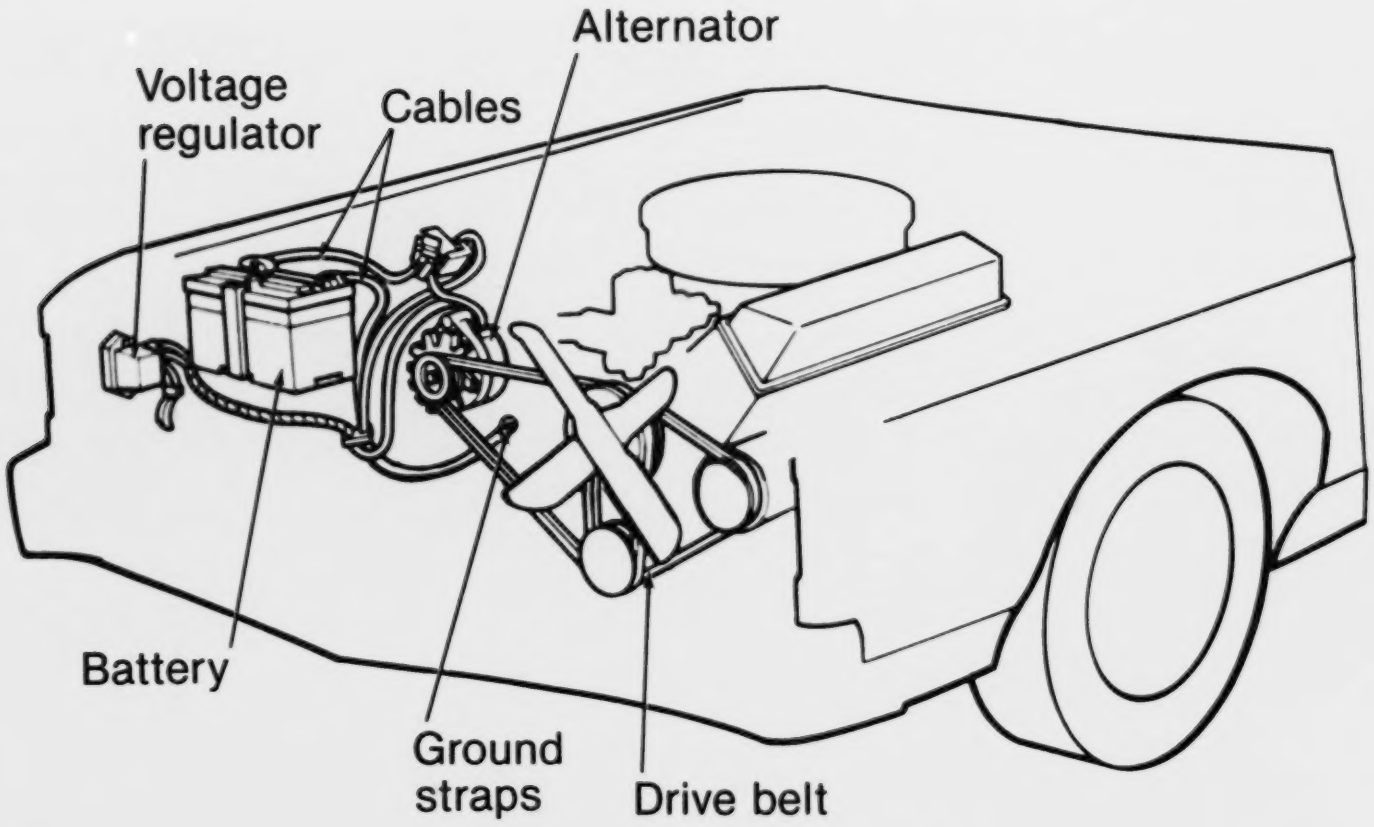
Brake System



FOUR DIFFERENT BRAKE DESIGNS ARE ILLUSTRATED.
IN PRACTICE, BRAKES ARE PAIRED, FRONT OR REAR.

Used with permission of Raybestos/Brake Systems Inc.

Charging System



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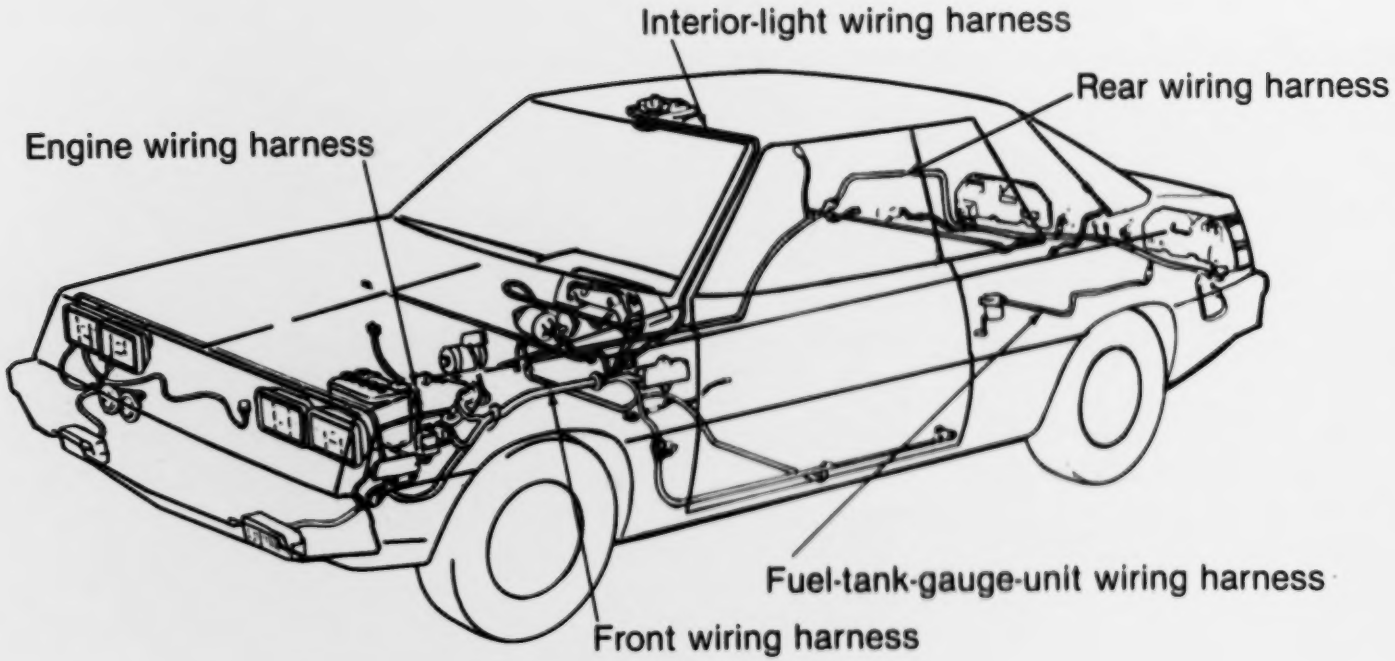
Chassis Electrical System



Major harness assemblies

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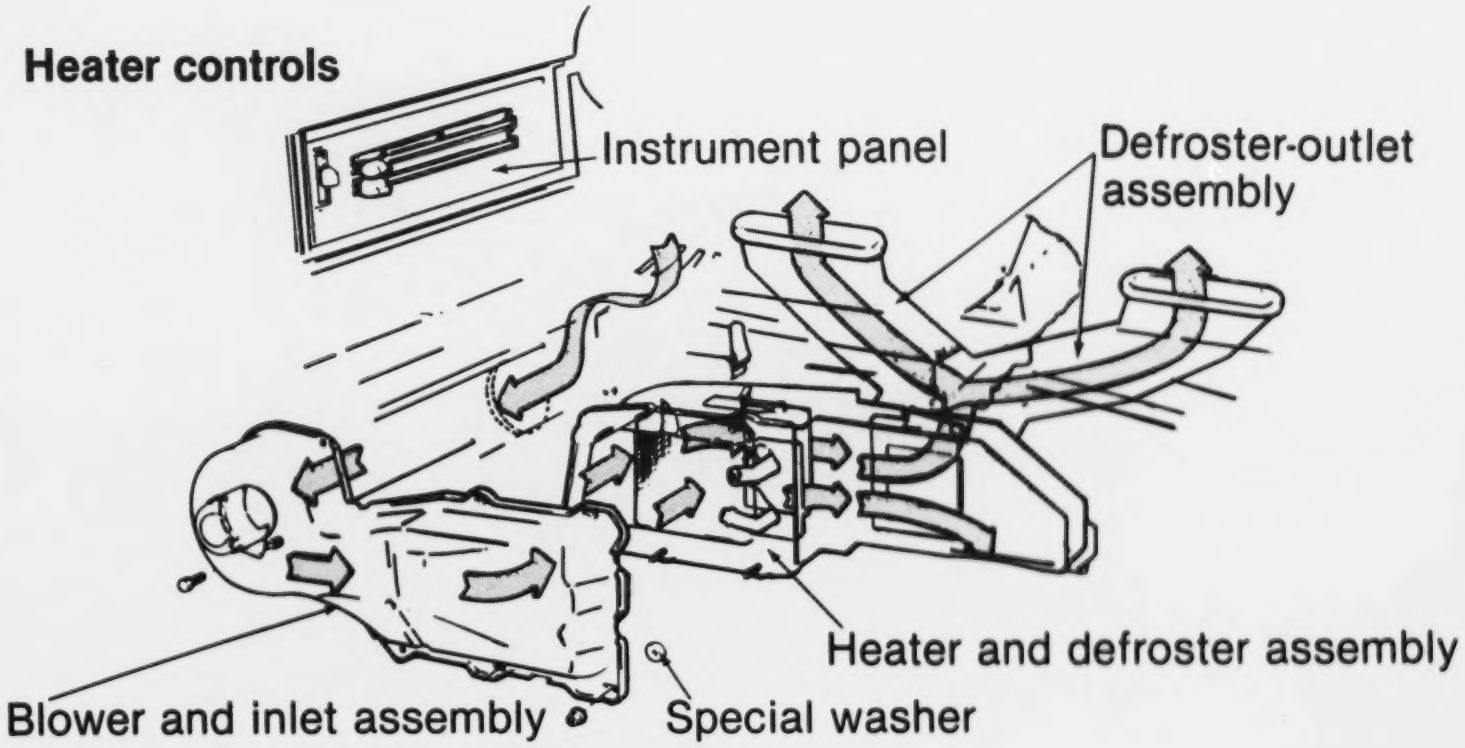
Heating System



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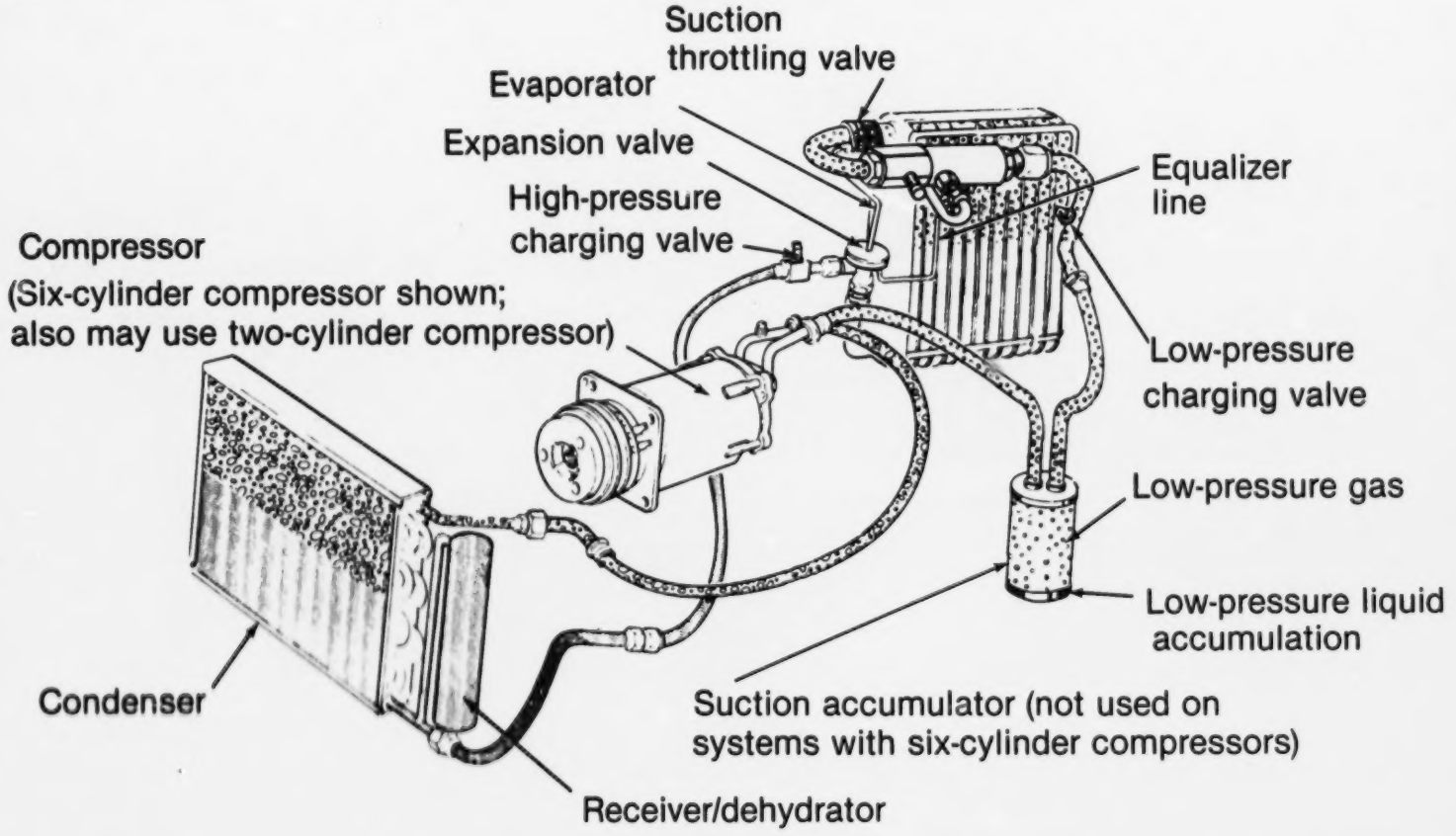
Air-Conditioning System



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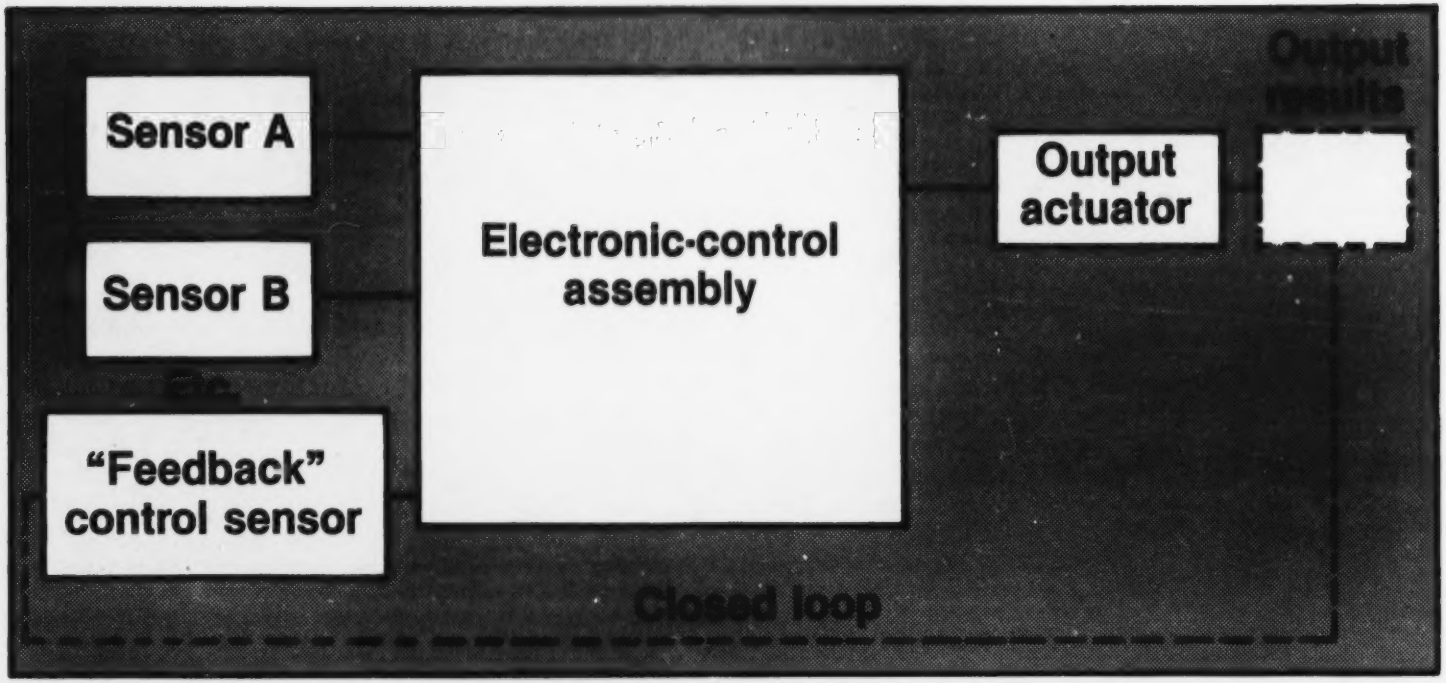
Computer-Control System



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PRETEST ANSWERS

STUDY AUTOMOTIVE DESIGN

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 18, 23, 34, 40
2	2, 3, 4, 41, 43
3	24, 48
4	25, 49
5	17, 20, 22
6	16
7	27
8	5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 37, 38, 46, 47
9	26
10	8, 19, 28, 29, 30, 31, 35
11	32
12	33
13	21
14	36, 39, 42, 44, 45, 50

ANSWER KEY

1. c
2. b
3. d
4. a
5. a
6. c
7. b
8. c
9. b
10. c
11. c
12. c
13. d
14. a
15. d
16. a
17. b
18. d
19. a
20. d
21. a
22. d
23. b
24. a
25. d
26. d
27. c
28. b
29. b
30. b
31. a
32. a
33. d
34. c
35. a
36. a
37. d
38. a
39. c
40. d
41. c
42. d
43. b
44. d
45. c
46. c
47. a
48. b
49. c
50. b

585

PRETEST

STUDY AUTOMOTIVE DESIGN

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. The best definition for an automotive *system* is

   a. Member of a component or system; two or more parts that function together in a component or system
   b. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function
   c. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
   d. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point

2. Which of the following best describes a functional purpose of a vehicle's body?

   a. Supports vehicle
   b. Holds, carries, and protects passengers and cargo
   c. Provides source of power to move vehicle
   d. Carries engine power to driving wheels

3. The functional purpose of a vehicle's chassis is to

   a. Support the engine
   b. Support the wheels
   c. Support the body
   d. All of the above

4. Which of the following best describes the functional purpose of a vehicle's drivetrain?

   a. Carries engine power to driving wheels
   b. Supports the engine
   c. Encloses engine
   d. Supports the body

5. Which of the following best describes a purpose of the steering system?

   a. Allows driver to turn front wheels right or left to control vehicle direction
   b. Allows cornering without extreme body roll
   c. Carries engine power to driving wheels
   d. Absorbs road shock that results from wheels hitting holes or bumps

6. Which of the following is a purpose of the suspension system?

   a. Absorbs road shock that results from wheels hitting holes or bumps
   b. Allows cornering without extreme body roll
   c. Both a and b
   d. Neither a nor b

7. Which of the following is a purpose of the fuel system?

   a. Controls and powers electric motor used to start engine easily
   b. Mixes fuel with air in proper proportions for efficient burning in engine
   c. Cleans engine by removing contaminants
   d. Reduces friction by providing lubrication around and between moving parts or contact points within engine

8. Technicians A and B are discussing guidelines for checking a vehicle's steering-fluid level. Technician A says that a manual-steering system requires very little service other than a periodic check of the lubricant level in the steering gearbox. Technician B says that to perform the fluid-level check on a manual-steering system a filler plug at the top of the gearbox is removed and a visual check made to make sure the fluid level covers the gear.

   Who is right?

   a. Technician A
   b. Technician B
   c. Both A and B
   d. Neither A nor B

9. Which of the following is a purpose of the emission-control system?

   a. Produces, controls, and monitors electrical current needed while vehicle is running
   b. Promotes clean, efficient burning of fuel mixture within combustion chamber
   c. Pulls warm air from passenger compartment to be cooled, dehumidified, and cleaned, and then returns air back to passenger compartment
   d. Circulates air and liquid to transfer heat caused by combustion and by friction away from engine to prevent engine damage

10. The purpose of the chassis electrical system is to

   a. Provide wiring connections
   b. Control and power electric motor used to start engine easily
   c. Power safety and warning devices, convenience accessories, and lights
   d. Produce spark that ignites air/fuel mixture and begins combustion in engine combustion chambers

11. The purpose of the starting system is to

   a. Produce spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
   b. Power safety and warning devices, convenience accessories, and lights
   c. Control and power electric motor used to start engine easily
   d. Produce, control, and monitor electrical current needed while vehicle is running

12. The primary purpose of the ignition system is to

   a. Produce, control, and monitor electrical current needed while vehicle is running
   b. Control and power electric motor used to start engine easily
   c. Produce spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
   d. Power safety and warning devices, convenience accessories, and lights

13. A purpose of the engine lubrication system is to

   a. Reduce friction by providing lubrication around and between moving parts or contact points within engine
   b. Clean engine by removing contaminants
   c. Help transfer heat to cool engine
   d. All of the above

14. The purpose of the engine cooling system is to

    a. Circulate air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
    b. Pull warm air from passenger compartment to be cooled, dehumidified, and cleaned, and then return air back to passenger compartment
    c. Clean engine by removing contaminants
    d. Direct harmful gases and heat away from engine

15. Which of the following statements best describes a purpose of the heating and air-conditioning system?

    a. Keeps engine at its most efficient operating temperature
    b. Helps transfer heat to cool engine
    c. Directs harmful gases and heat away from engine
    d. Heats outside air and circulates heated air into passenger compartment

16. Which of the following is **not** an engine classification factor?

    a. Automatic or manual
    b. Cooling-system type
    c. Air/fuel-mixture control method
    d. Valve arrangement

17. Which of the following best describes the power stroke in the operation of a four-stroke-cycle piston engine?

    a. Piston moves up cylinder, compressing air/fuel mixture and creating heat, which prepares fuel for instant ignition
    b. Piston reaches top of cylinder and a spark from ignition system ignites air/fuel mixture; burning gases expand rapidly and force piston down cylinder
    c. Piston reaches bottom of cylinder and exhaust valve opens; piston travels up cylinder, forcing burned gases out of cylinder and into exhaust manifold
    d. All of the above

18. In automotive terms, to *reinstall* means to

    a. Take a part, assembly, or component from its location
    b. Secure a previously removed or a replacement part, assembly, or component in its proper location
    c. Secure a replacement part, assembly, or component in its proper location
    d. Secure a previously removed part, assembly, or component in its proper location

19. Technicians A and B are discussing the steps in checking the automatic-transmission fluid level. Technician A says to leave the engine running at curb-idle speed during the check. Technician B says the engine should not be running during the check.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

20. Which of the following is the correct sequence of strokes in the operation of a four-stroke-cycle piston engine?

a. Intake, power, compression, exhaust
b. Intake, compression, exhaust, power
c. Intake, exhaust, compression, power
d. Intake, compression, power, exhaust

21. Technicians A and B are discussing proper procedures for checking tire air pressure. Technician A says that tire air pressure must be checked only when the tires are cold. Technician B says that the check must be made just after the vehicle has been driven at least 20 miles to make sure the tires are still hot and are at maximum air pressure.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

22. Which of the following best describes the intake stroke in the operation of a four-stroke-cycle piston engine?

a. Piston moves up cylinder, compressing air/fuel mixture and creating heat, which prepares fuel for instant ignition
b. Piston reaches bottom of cylinder and exhaust valve opens; piston travels up cylinder, forcing burned gases out of cylinder and into exhaust manifold
c. Piston reaches top of cylinder and a spark from ignition system ignites air/fuel mixture; burning gases expand rapidly and force piston down cylinder
d. Piston is located at topmost position in cylinder with intake valve open and exhaust valve closed; piston moves down cylinder, drawing air/fuel mixture into cylinder from carburetor; piston reaches bottom of cylinder and intake valve closes

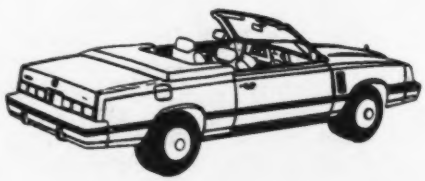
23. The definition "member of a component or system; two or more parts that function together in a component or system" best describes which of the following terms?

a. Part
b. Assembly
c. Component
d. System

24. Which of the following illustrations depicts a hardtop vehicle?

a.

b.



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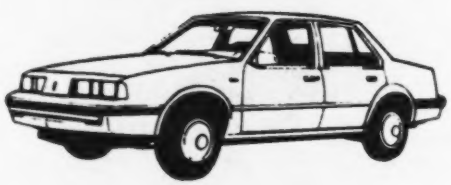

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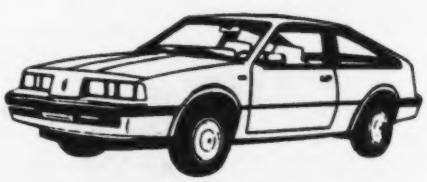

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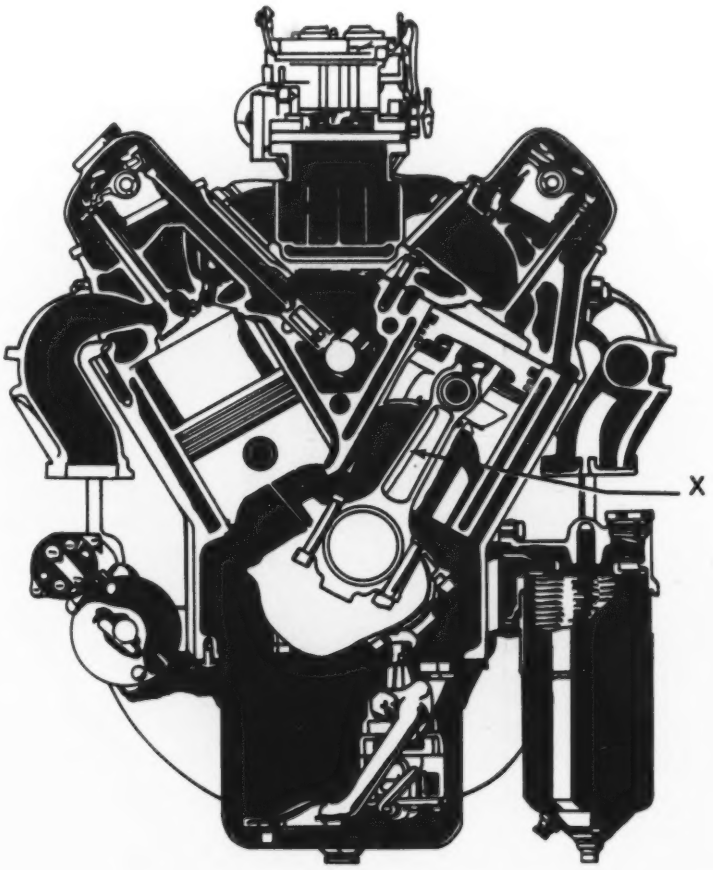
25. Component X shown in the illustration below is called a

a. Camshaft
b. Crankshaft
c. Exhaust manifold
d. Connecting rod



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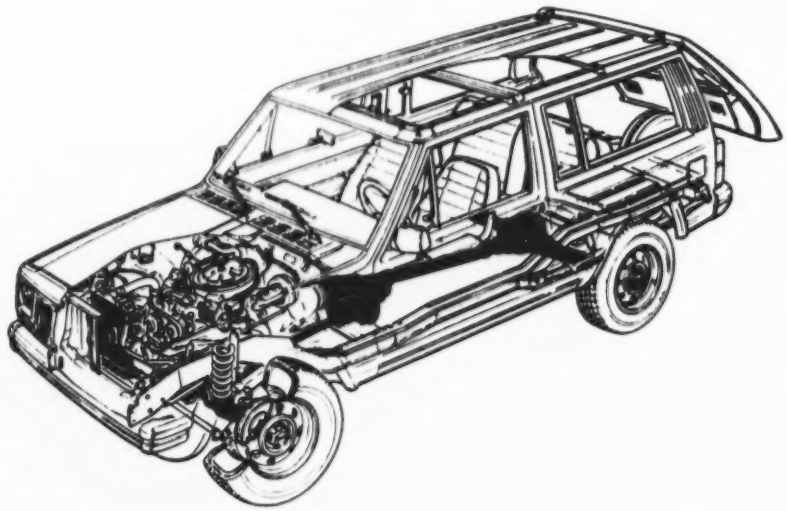
26. Vehicles can be classified according to their power-train design, which is determined by the engine location and drivetrain design. The power train of the vehicle shown in the illustration below can best be described as a

a. Front-engine, rear-wheel-drive
b. Front-engine, front-wheel-drive
c. Mid-engine, rear-wheel-drive
d. Front-engine, four-wheel-drive



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27. Which of the following is **not** a reason for cleaning a vehicle's engine?

a. Grease, oil, gasoline, and dirt build up as grime that can deteriorate rubber parts and wiring
b. Grime buildup can cause the engine to run hotter than normal
c. A clean engine gets a higher blue-book rating
d. Grime buildup on the engine can cause rust to form on metal parts

28. Which of the following guidelines does **not** apply when checking engine-oil level?

a. Engine-oil level is checked on a dipstick, which is located on the crankcase and protrudes down into the oil pan
b. Oil is added only when the level on the dipstick is slightly above the ADD OIL mark
c. The vehicle should be on level ground when the check is performed
d. The vehicle's engine should not have been running for at least 10 minutes to allow oil to drain back into the crankcase

29. Technicians A and B are discussing guidelines for checking coolant level on vehicles without a recovery system. Technician A says that you may remove the radiator cap when the engine is hot from running, as long as you wrap a cloth around the cap to protect your hand. Technician B says that you should never attempt to remove the cap when the engine is hot and that the system must be tested by squeezing the upper radiator hose with your hand.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

30. When checking coolant level on a vehicle with a coolant recovery system, you should follow all of the guidelines below **except**

a. Check the coolant level in the engine reservoir; do not remove the radiator cap
b. Always check the coolant level when the engine is running
c. The reservoir has two marks: one for showing the level when the engine is hot and one for when the engine is cold
d. In this type of system, the expansion reservoir is connected to the radiator filler cap

31. When checking brake-fluid level, follow all of the guidelines below **except**

a. Fill master cylinder to proper level: diaphragm-reservoir master cylinder should be no more than one-half full; composite-reservoir master cylinder should be filled to the FILL TO mark
b. Brake fluid is poison; keep it away from your skin and eyes
c. Brake fluid will damage chrome and painted surfaces; do not allow it to drip on these surfaces
d. Brake fluid is flammable; keep it away from fire

32. Periodic battery service involves all of the following **except**

a. Storing battery electrolyte properly
b. Visually inspecting the battery
c. Cleaning corrosion from battery terminals and clamps
d. Checking battery electrolyte level (if possible)

33. When inspecting drive belts, which of the following guidelines should be followed?

a. Small cracks can be found by flexing a belt and twisting it at the same time
b. Check the underside of all belts; belts may appear sound from the top, but may have splits on the bottom
c. Neither a nor b
d. Both a and b

34. The best definition of *inspect* is

a. To take a part, assembly, or component from its location
b. To take apart an assembly, component, or system
c. To examine a part, assembly, or component for wear, damage, size, or shape
d. To determine whether a substance or object is present and meets specifications; to determine whether an event takes place

35. When checking the windshield-washer-fluid level, follow all the guidelines below **except**

a. Locate windshield-washer-fluid dipstick, remove reservoir cover, and check fluid level
b. Check to make certain you have located the windshield-washer-fluid reservoir
c. Windshield-washer-fluid reservoirs are made of transparent plastic; you will be able to see the fluid level without removing the reservoir cover
d. The windshield-washer-fluid reservoir can be confused with the coolant recovery reservoir

36. When conducting a safety inspection of the exhaust system, follow all of the guidelines below **except**

a. Muffler repairs such as welds, jackets, and patches are allowed as long as permanent-type welds have been used in making the repairs
b. Do not touch hot exhaust-system components
c. The procedure must be performed when the vehicle is running; follow all safety precautions for preventing carbon-monoxide poisoning
d. The vehicle must be properly elevated when this procedure is performed; follow all safety precautions for properly elevating a vehicle

37. Which of the following best describes the function of a vehicle's charging system?

a. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
b. Controls and powers electric motor used to start engine easily
c. Powers safety and warning devices, convenience accessories, and lights
d. Produces, controls, and monitors electrical current needed while vehicle is running

38. All of the following are purposes of the brake system **except**

a. Allows cornering without extreme body roll
b. Allows driver to reduce speed of moving vehicle
c. Allows driver to stop moving vehicle
d. Holds vehicle stationary when parked

39. Glazing materials marked AS-6 and AS-7 may be used in which of the following positions in vehicles?

a. In windshields
b. Anywhere except windshields
c. In rear windows of soft tops, flexible curtains, or readily removable windows
d. In folding doors, standee, and rearmost windows in buses, or in windows to the rear of the driver in trucks or truck tractors

40. Which of the following best defines the term *automotive design*?

a. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
b. Group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system
c. System defined by the flow of gas, liquid, or power from a given point or from a given point through to its return to that point
d. Plan of the shape of and the materials to be used for elements of a vehicle and of the way these elements fit together and function to achieve certain purposes

41. Which of the following best describes the functional purpose of a vehicle's engine?

a. Carries power to driving wheels
b. Supports wheels and body
c. Provides source of power to move vehicle
d. None of the above

42. Technicians A and B are discussing the correct procedure for measuring tire-tread depth. Technician A says that two measurements should be taken on each tire's tread shoulder and these measurements must be at least 12 inches apart. Technician B says that the two measurements must be taken at least 12 inches apart along the major groove at the center of each tire.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

43. Which of the following best describes the functional purpose of the drivetrain?

a. Transmits road feel to driver's hands
b. Carries engine power to driving wheels
c. Allows driver to turn front wheels right or left to control vehicle direction
d. Allows cornering without extreme body roll

44. Technicians A and B are discussing the guidelines for conducting a safety inspection of a vehicle's steering system. Technician A says that steering lash is any obstruction to the turning of the steering wheel that is caused by interference with any component of the steering system and that the test for steering lash must be conducted while the vehicle is on a dry, level surface. Technician B says that steering lash is the distance in which the steering wheel can be turned through some part of a revolution without front-wheel motion and that the test for steering lash must be conducted while the vehicle is elevated.

    Who is right?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

45. Which of the following is the best definition of *outright breakage* of glazing material?

    a. Vented breaks with cracks radiating from the point of impact
    b. Cracks with no point of impact
    c. Severely cracked or shattered glazing material damaged to the extent that air passes through it
    d. None of the above

46. Which of the following is a purpose of the exhaust system?

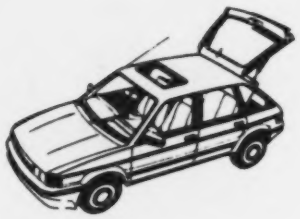
    a. Reduces noise caused by the combustion process within the engine
    b. Directs harmful gases and heat away from engine
    c. Both a and b
    d. Neither a nor b

47. Which of the following best describes the purpose of the computer-control system?

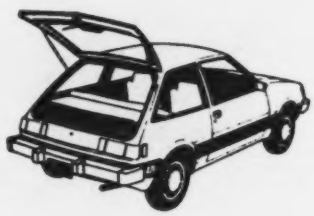
    a. Electronically monitors operation of various systems and adjusts those systems or provides driver or service person with information about those systems
    b. Produces, controls, and monitors vehicle systems while vehicle is running
    c. Powers safety and warning devices, convenience accessories, and lights
    d. All of the above

48. Which of the following illustrations depicts a three-door sedan?

a.



b.



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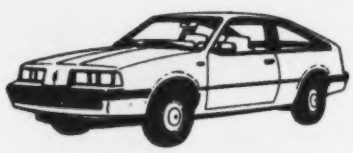

d.

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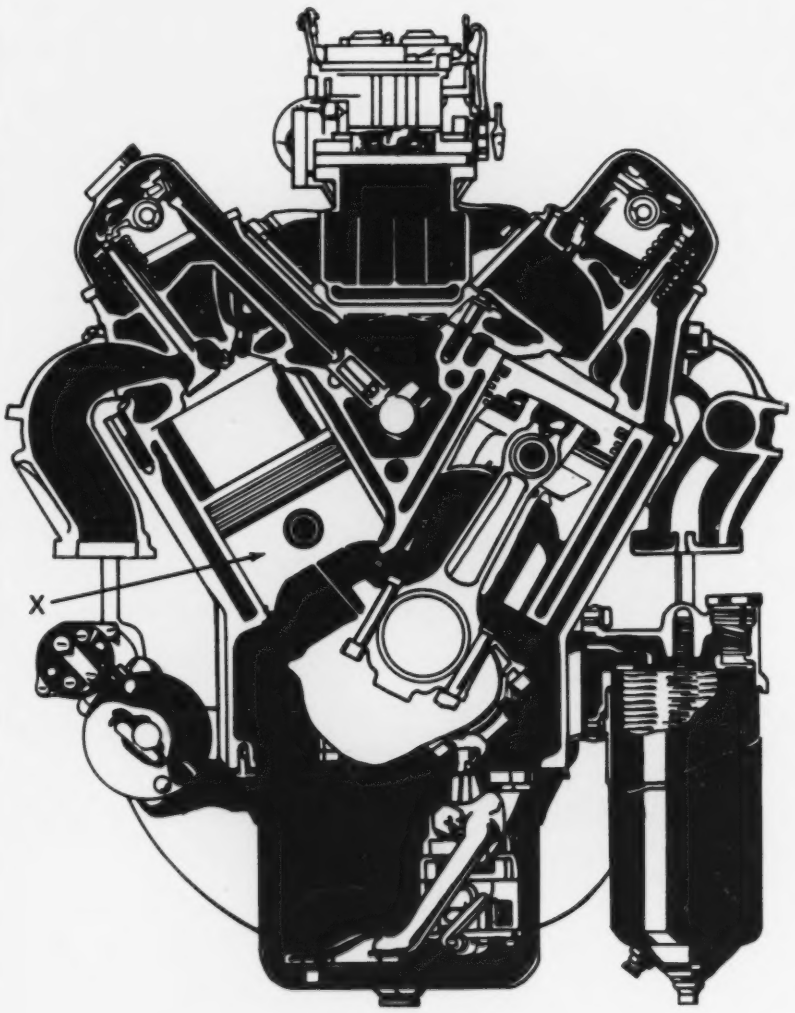
49. Component X shown in the illustration below is called a

a. Camshaft
b. Connecting rod
c. Piston
d. Crankshaft



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50. Technicians A and B are discussing the procedure for checking brake-pedal reserve when conducting a safety inspection of the brake system. Technician A says the brake pedal on power-assisted systems and on hydraulic or mechanical systems should have at least a 1-inch clearance from the bottom of the brake pedal to the floor. Technician B says that a 1-inch clearance is accurate only on power-assisted systems.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

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INFORMATION SHEET	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 1

Recognize definitions of terms associated with automotive design

Automotive design — Plan of the shape of and the materials to be used for elements of a vehicle and of the way these elements fit together and function to achieve certain purposes

EXAMPLE: If one purpose of the design of a vehicle is to achieve good fuel economy, then the designer will consider ways to make the vehicle's engine more efficient.

Part — Element of an assembly or component; member that is not normally useful by itself and cannot be disassembled further

EXAMPLES: Bolts, springs, rods, housings, gaskets, tires

Assembly — Member of a component or system; two or more parts that function together in a component or system

EXAMPLES: Nut and bolt; tire and wheel; piston, connecting rod, rod cap, and rod bolts; gear assemblies

Component — Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

EXAMPLES: Fuel pump, carburetor, air-conditioner compressor, transmission, brake master cylinder

Parts, Assemblies, or Components

Normally, *parts* are objects manufactured as a single piece of one material. However, in some cases, a part may be made of more than one kind of material but manufactured in such a way that it cannot be disassembled without making it unsuitable for its designed purpose. The normal service for a part is replacement, although some adjustments are possible with some parts, such as rethreading a bolt, bending a rod, or patching a tire. In most cases such adjustments will be considered temporary and will often not be cost-effective or in compliance with industry standards.

Assemblies are generally a group of parts that are used together to perform a specific function in the design or operation of a component or system. Service usually consists of replacing parts or adjusting the relationship between the parts.

The term *components* may be applied to those parts and assemblies that make up a system. Service of components becomes complex because of the number of parts involved. Most ASE tasks involve the inspection, testing, and maintenance of components.

Circuit — Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point

EXAMPLES: Fuel circuit, engine lubrication circuit, starting circuit, power-flow circuit through transmission

System — Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function

EXAMPLES: Steering system, suspension system, brake system, fuel system, exhaust system

Remove — To take a part, assembly, or component from its location

Replace — To secure a replacement part, assembly, or component in its proper location

Install — To secure a previously removed or a replacement part, assembly, or component in its proper location; to add a completely new assembly or component

Reinstall — To secure a previously removed part, assembly, or component in its proper location

Disassemble — To take apart an assembly, component, or system

Check — To determine whether a substance or object is present and meets specifications; to determine whether an event takes place

Inspect — To examine a part, assembly, or component for wear, damage, size, or shape

Combustion — Process of burning

Friction — Resistance to motion between two parts in contact

Contaminant — Undesirable element

EXAMPLES: Carbon buildup on combustion chamber parts; carbon sludge in engine oil

Cycle — Event or series of events that is repeated

Install, Reinstall, or Replace

The term *install* is used when it is not possible to specify whether the same part or a replacement part will be used. For example, if a part will be inspected and either *replaced* or *reinstalled* depending on its condition, the procedure might say "install the old part or a new one." If there is no reason to suspect that a part would need to be replaced, the procedure would probably say "reinstall," while for a part such as a gasket that cannot be reused, the procedure might say "replace the part with a new one."

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OBJECTIVE 2

Recall major functional areas of a vehicle and their purpose(s)

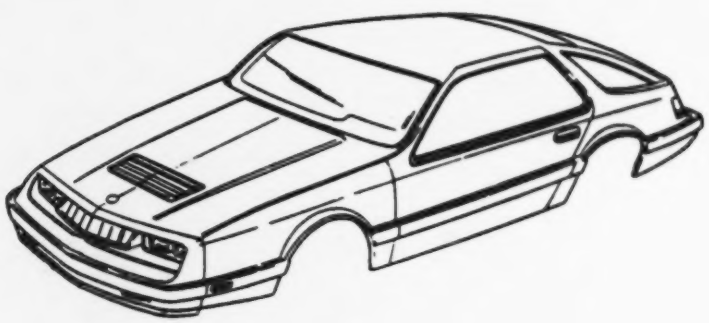
Body

- Holds, carries, and protects passengers and cargo
- Encloses engine

The Automobile Body: A Comfortable, Safe Enclosure

The automobile body is the enclosure that the driver and the passengers ride in, and the body shape is probably the first thing people notice about an automobile's design. However, besides shielding people from the weather and creating a desirable image, the automobile body also protects the driver and passengers in a crash.

The bodies of early automobiles were little more than a platform with seats attached. But modern automobile body design takes into account much that has been learned about safe construction. Today, most automobile bodies are constructed of sheet-steel components shaped in giant punch presses and welded to form a tight, safe, rattle-free unit.



Body

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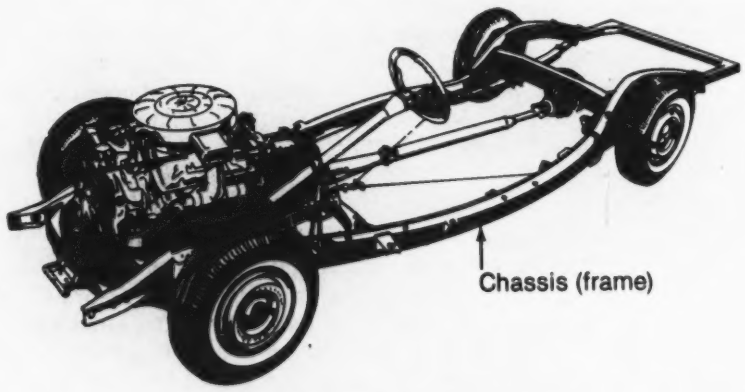
Chassis (frame)

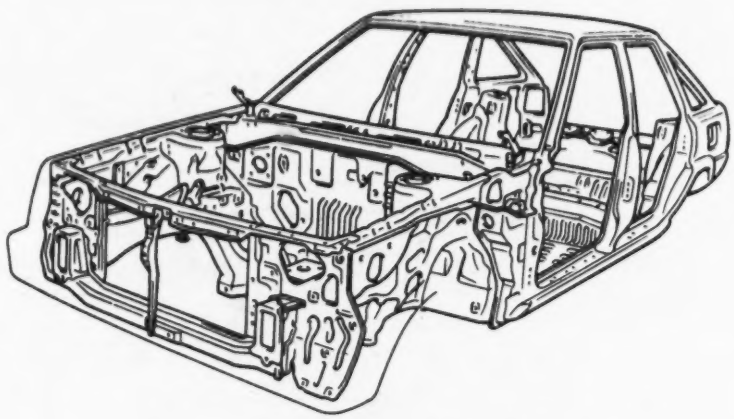
- Supports engine, wheels, and body

Chassis Design

In conventional chassis design (as in illustration a), the body and frame are separate units bolted together, but in unitized design (see illustration b), body and frame are one unit.



(a) **Conventional chassis design**



(b) **Unitized-body-and-frame design**

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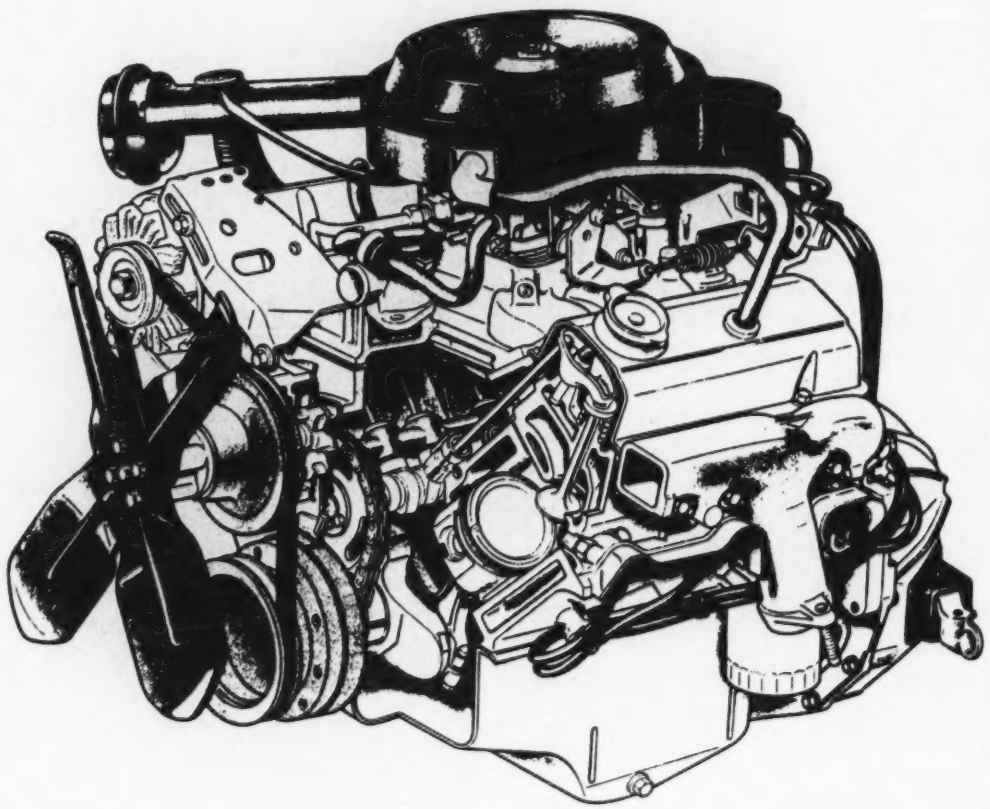
Engine

- Provides source of power to move vehicle

Automobile Engine

An engine is a machine that converts heat energy into mechanical energy. An automobile engine burns fuel to produce mechanical power; for this reason, the automobile's engine is sometimes called the *power plant*.

There are many kinds of engines: gasoline engines, diesel engines, steam engines, gas-turbine engines, jet engines, and rocket engines. The two most commonly used in automobiles and trucks are the gasoline engine and the diesel engine.



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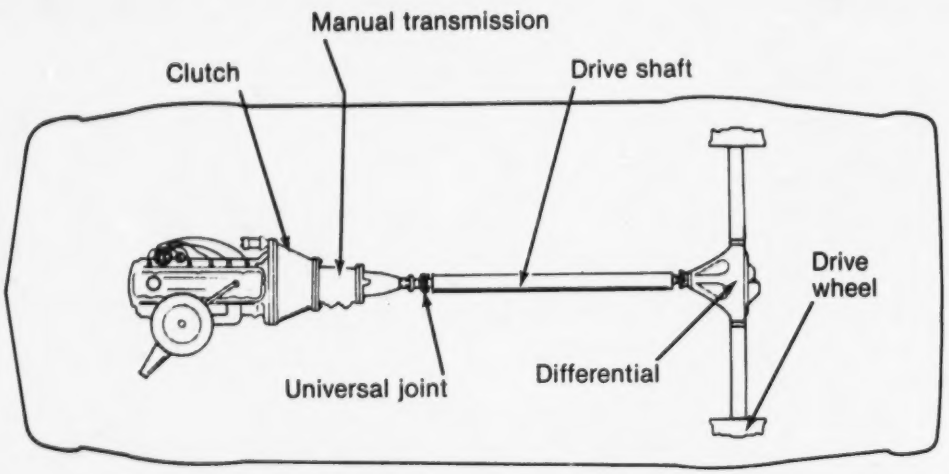
Drivetrain

- Carries engine power to driving wheels

NOTE: The purpose of the drivetrain is to carry the power of the engine to the driving wheels. But you will also hear the term *power train* in reference to this same purpose. And you may find that the drivetrain and the power train consist of many of the same components: clutch, transmission, drive shaft, etc. But there is a difference between the drivetrain and the power train. The power train includes the engine; the drivetrain does not.

Drivetrain Update

The clutch (on vehicles with manual transmissions), transmission (either manual or automatic), universal joint, drive shaft, differential, and drive wheels—these are the mechanisms that make up the traditional drivetrain and carry the power produced by a front-mounted engine to the driving wheels at the rear. (See the illustration below.) However, today many vehicles have front-wheel and four-wheel drive, which require new mechanisms to be added to the traditional makeup of the drivetrain. On vehicles with front-wheel drive, the engines are transversely mounted and require a different transmission-and-differential assembly. This new-type assembly is called a *transaxle*. Vehicles with four-wheel drive require a *transfer case*. A transfer case is used to transfer some power to a second set of drive wheels—all the time for full-time four-wheel drive or as needed for part-time four-wheel drive. This normally means power goes from the transfer case to the front wheels, but a few vehicles are normally front-wheel drive with part-time rear-wheel drive.



Traditional drivetrain with manual transmission

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OBJECTIVE 3 | **Identify major vehicle body styles**

FIGURE 1

(a) Two-door sedan

(b) Three-door sedan (hatchback)

(c) Four-door sedan

(d) Five-door sedan (hatchback)

(e) Hardtop

(f) Convertible

(g) Limousine

(h) Station wagon

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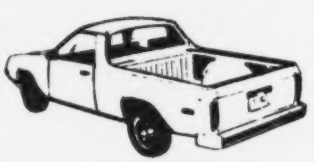
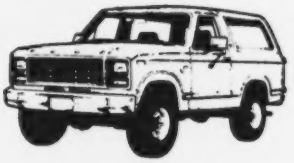
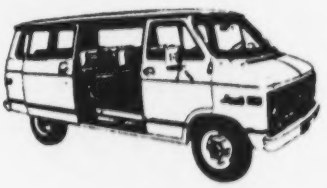
FIGURE 1 (cont.)



(i) Pickup truck



(j) Utility vehicle



(k) Van

Iacocca on the Importance of Body Style

Lee Iacocca, chief executive officer of the Chrysler Corporation, knows the importance great body styling plays in the success of a vehicle. In his book, *Iacocca: An Autobiography*, he recounts a story of the tremendously successful T115 minivan.

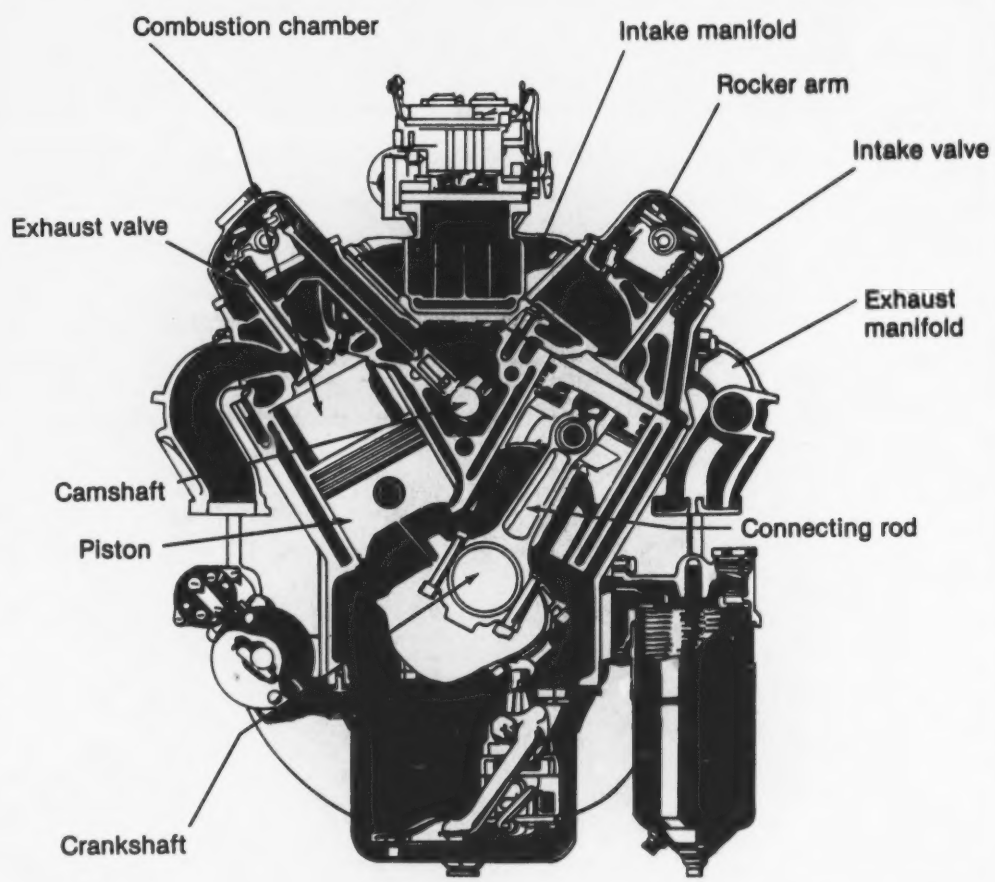
In the late 70s shortly after the first OPEC crisis, when he was working for Ford, Iacocca and Hal Sperlich came up with the idea for the Mini-Max—a small van that would be compact enough to get good gas mileage, yet roomy enough to hold several passengers. They were so certain of the public's acceptance of the Mini-Max that they spent $500,000 on researching the project, but ultimately, Iacocca and Sperlich could not sell Henry Ford on the idea, and the project was shelved at Ford.

In 1984, now heading Chrysler and still certain the public would respond positively to the project, Iacocca and Sperlich unshelved the Mini-Max idea, perfected the design, and introduced the minivan—a vehicle for people who wanted something slightly bigger than a station wagon but smaller than a conventional van; something that would hold seven passengers, have front-wheel drive, get 30 miles to the gallon, and still fit into a typically sized garage. And he was right—even before the minivan came out, *Connoisseur* magazine selected it as one of the most beautiful cars ever designed, *Fortune* named it one of the ten most innovative products of the year, and car-buff magazines featured it on their covers months before it went on sale. Iacocca says that not since the unveiling of the Mustang in 1964 was he as excited about a new product—and as confident of its success.

OBJECTIVE 4 | Recall basic components of a piston engine

NOTE: As previously stated, the engine is the vehicle's power source. Two major types of engines are used in vehicles today: the piston engine and the rotary engine. As the names suggest, the piston engine contains pistons that move up and down, while the rotary engine contains a rotor that spins. The four-stroke-cycle piston engine is the most commonly used engine in American automobiles; therefore, it will be helpful for you to become familiar with the basic parts of that engine and the basic principles of its operation. Basic engine parts are presented in this objective and basic principles of operation are discussed in the next objective.

FIGURE 2



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OBJECTIVE 5

Explain the operation of a four-stroke-cycle piston engine

Intake stroke (Figure 3-a)

1. Piston is located at topmost position in cylinder (top dead center [TDC]) with intake valve open and exhaust valve closed
2. Piston moves down cylinder, drawing air/fuel mixture into cylinder from carburetor
3. Piston reaches bottom of the cylinder (bottom dead center [BDC]) and intake valve closes

Compression stroke (Figure 3-b) — Piston moves up cylinder, compressing air/fuel mixture and creating heat, which prepares fuel for instant ignition

Power stroke (Figure 3-c)

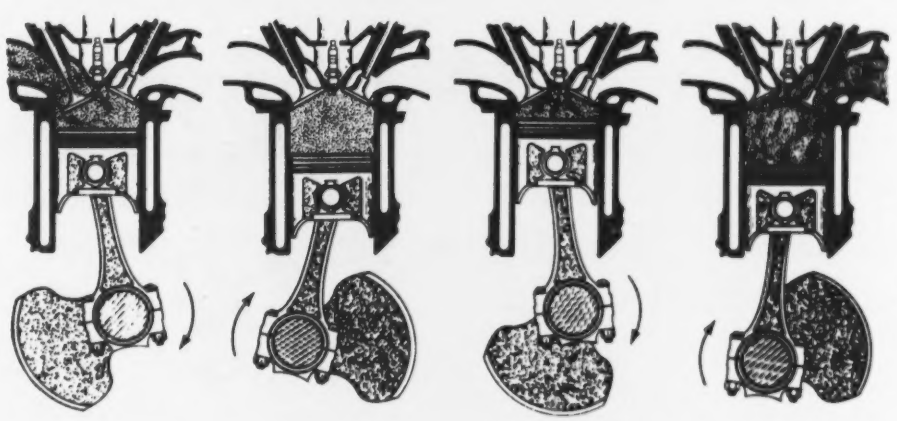
1. Piston reaches top of cylinder and a spark from ignition system ignites air/fuel mixture
2. Burning gases expand rapidly and force piston down cylinder

Exhaust stroke (Figure 3-d)

1. Piston reaches bottom of cylinder and exhaust valve opens
2. Piston travels up cylinder, forcing burned gases out of cylinder and into exhaust manifold

EXAMPLE:

FIGURE 3



(a) Intake (b) Compression (c) Power (d) Exhaust

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OBJECTIVE 6

Recall engine classification factors

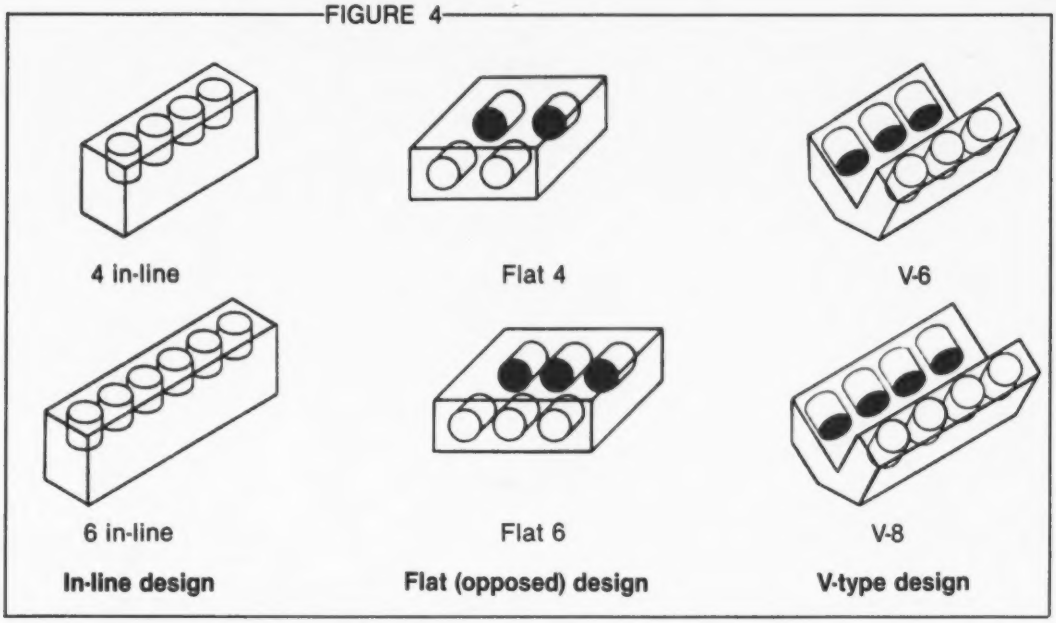
Cylinder number — American-made passenger-car engines generally are limited to four, six, or eight cylinders; foreign-made passenger-car engines are designed with three, four, five, six, or twelve cylinders

Cylinder arrangement (Figure 4) — Cylinders are arranged in three basic patterns: in a row (in-line), in two rows set at an angle (V-type), or in two rows opposing each other (flat)

NOTE: The arrangement most often used in American-made vehicles is the V-type, where the V-shaped rows come together at the bottom and have connecting rods all fastened to the same crankshaft and two pistons and two connecting rods for each crank pin.

EXAMPLE:

FIGURE 4



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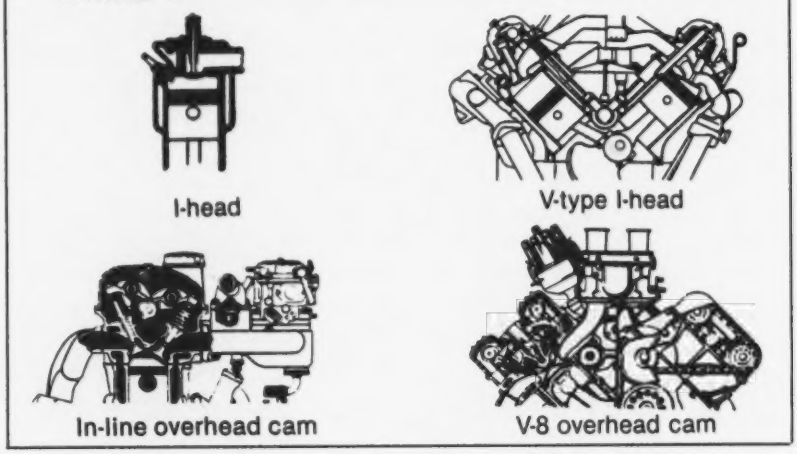
Valve arrangement (See Figure 5) — Engine intake and exhaust valves are arranged in four basic designs: I-head (overhead-valve), V-type I-head, in-line overhead camshaft, and V-8 overhead camshaft

NOTE: The I-head design is the one most commonly seen, but the overhead-camshaft-type is used when high engine speeds are required.

NOTE: Most engines have one intake and one exhaust valve per cylinder. However, some engines use two of each type of valve for each cylinder. Thus valve arrangement includes not only the placement of the valves but the number used.

EXAMPLE:

FIGURE 5



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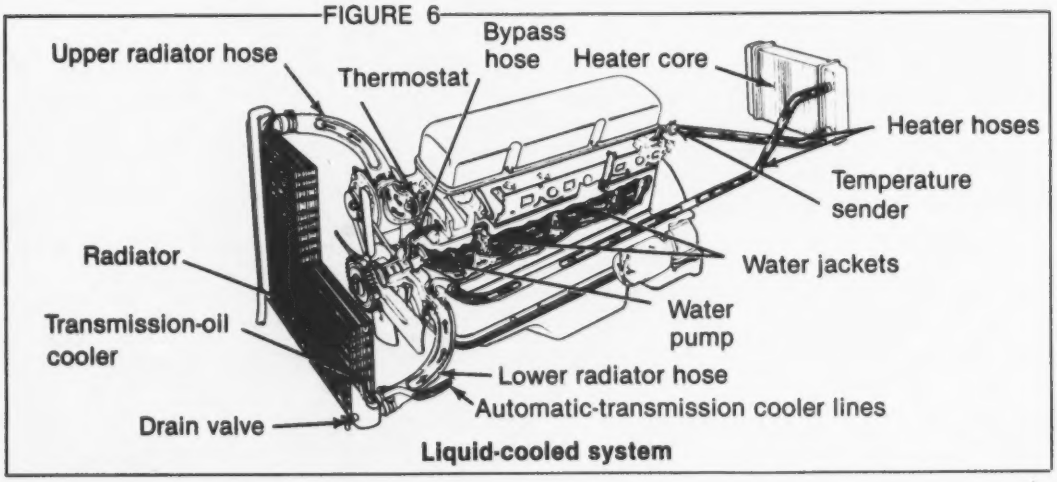
Cooling-system type — Two types of cooling systems are seen in engines: liquid-cooled and air-cooled

NOTE: Liquid-cooled engines use a coolant (water mixed with antifreeze) flowing through water jackets surrounding the cylinders and combustion chambers to cool the engine; most American automobile engines are cooled this way. See Figure 6. Some automobile engines, however, are air-cooled and have separate cylinders with metal fins and metal shrouds that direct airflow around the cylinders to carry the heat away.

EXAMPLE:

FIGURE 6



Used with permission of Chrysler Corporation.

Fuel type — Three fuels are used in internal combustion engines: gasoline (unleaded or leaded), liquid petroleum gas (LPG), or diesel fuel

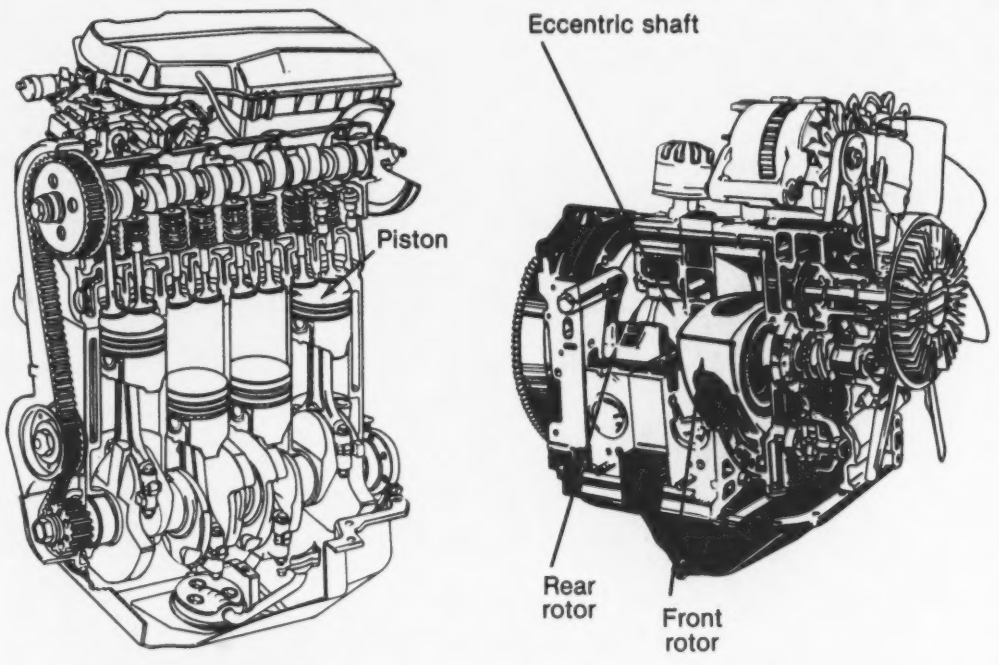
NOTE: Automobile engines usually have gasoline engines; some buses use liquid petroleum gas, and some trucks and automobiles use diesel fuel.

Basic engine motion — Two basic motions are produced by engines: reciprocating and rotary

NOTE: A reciprocating engine is one with pistons that move up and down (reciprocate) in the cylinders. A rotary engine has no pistons. Instead it has a rotor that is spun by the burning of the fuel in the engine. See Figure 7.

EXAMPLE:

FIGURE 7



(a) **Reciprocating** (b) **Rotary**

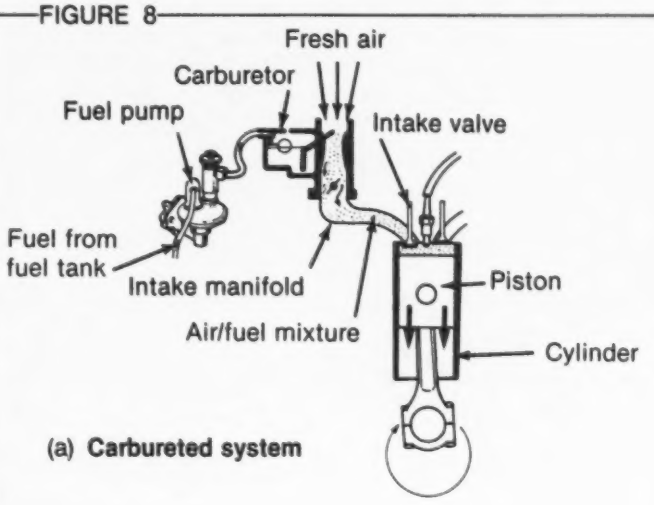
Illustration *a* used with permission of Chrysler Corporation. Illustration *b* used with permission of Mazda Motor Corporation, Hiroshima, Japan.

Air/fuel-mixture control method — Two systems are used to achieve proper air/fuel mixture in internal combustion engines: carbureted and fuel-injected

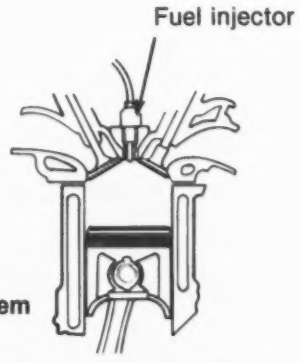
NOTE: In a carbureted system (see Figure 8-a), air and gasoline are mixed in proper portions in the carburetor and the mixture then flows from the carburetor to the engine cylinders. In a fuel-injected system (see Figure 8-b), the carburetor is replaced by a throttle body that controls the amount of air entering the intake manifold, and the fuel is injected either in the intake manifold or the intake port.

EXAMPLE:

FIGURE 8



(a) **Carbureted system**



(b) **Fuel-injected system**

Illustration *a* from *Engine Tune-Up Service, Unit 5: Fuel and Carburetion Systems*, 2nd ed., copyright © 1982, by State of Florida, Department of State. Used with permission of State of Florida, Department of State. Illustration *b* used with permission of Federal Mogul Corporation.

OBJECTIVE 8

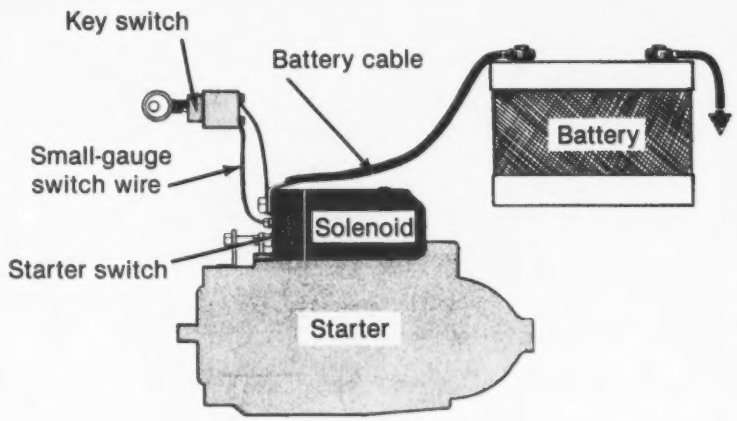
Recognize purpose(s) of the major systems of a vehicle

Starting system

- Controls and powers electric motor used to start engine easily

Thank You, Charles Kettering!

Drivers can all be thankful that an engineer named Charles F. Kettering invented the self-starting engine in 1912. (See the components of a modern starting system below.) Before that, automobiles had to be started with good old-fashioned elbow grease. The driver had to set the choke, go to the front of the car and insert a crank into the special slotted opening, jump back into the vehicle, and pull out the hand throttle, advance the spark using the manual control, turn the ignition on, then run back to the front of the car and spin the crank as rapidly as possible—watching out for the crank to spin backwards with enough force to break his/her arm should the engine misfire. And it was not at all unusual to have to repeat this entire process several times if the engine was cold.

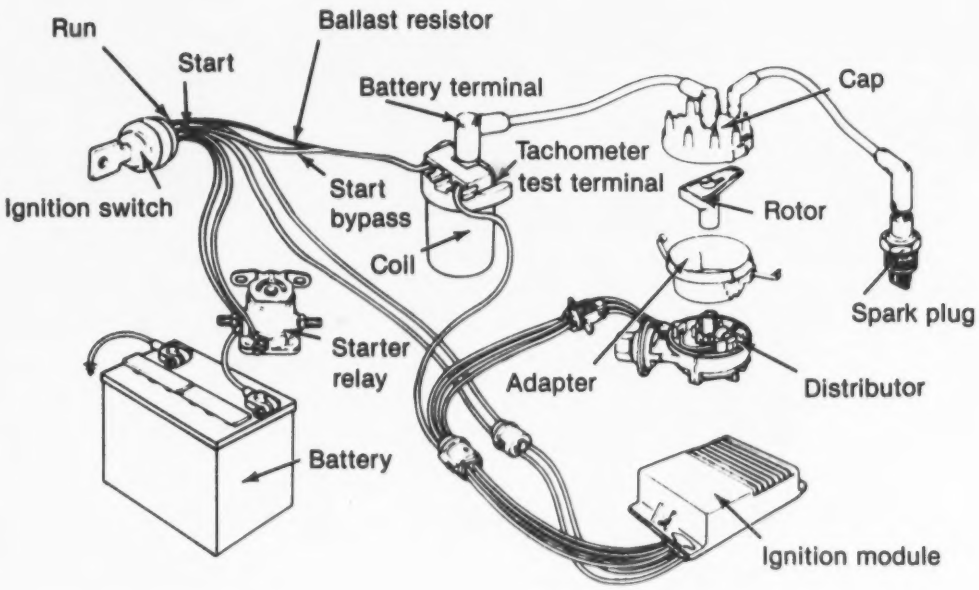


Ignition system

- Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers

Thank You Again, Charles Kettering!

In 1908, Charles Kettering, who also invented the electric starter, designed a basic spark ignition system consisting of a battery, ignition coil, switch, primary and secondary wiring connections, and a spark plug. Later this basic design was refined and the points-and-condenser ignition system was developed—only to be replaced in the early 1970s by the electronic ignition system (see the drawing below). Electronic ignition systems are used on all new engines, but the theory and operation of the point-type system is still taught because some of those old vehicles are still around.



Used with permission of Ford Motor Company.

Fuel system

- Provides fuel storage
- Delivers fuel to engine
- Mixes fuel with air in proper proportions for efficient burning in engine

Back to the Basics

Although modern fuel systems vary in design, a basic carbureted fuel system consists of a fuel tank, fuel lines, fuel pump, carburetor, intake manifold, intake port, and intake valve.

—The **fuel tank** is the vehicle's holding tank for fuel and stores 10 to 25 or more gallons, depending on the manufacturer.

—The **fuel lines** deliver fuel from the fuel tank to the fuel pump and carburetor.

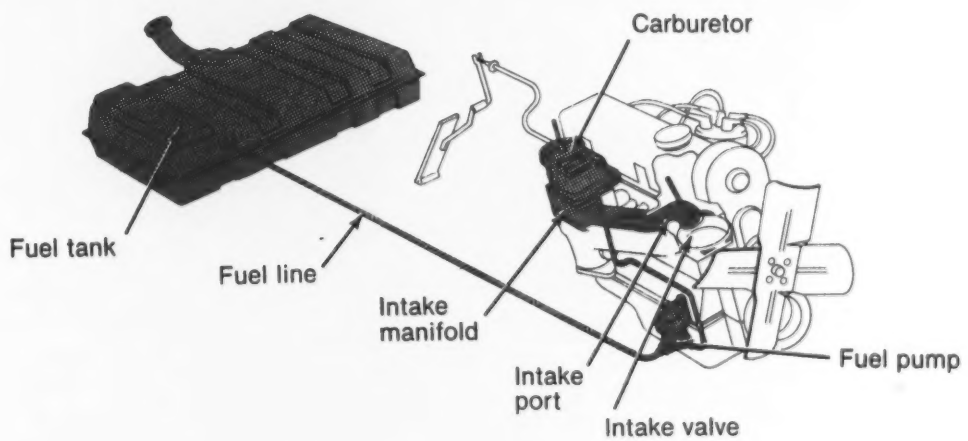
—The **fuel pump** pumps the fuel from the fuel tank through the fuel lines to the carburetor.

—The **carburetor** mixes the fuel with air in proper proportions for efficient burning.

—The **intake manifold** takes the air/fuel mixture from the carburetor and distributes it to all the cylinders.

—The **intake port** is an opening located between the intake manifold and the cylinders.

—The **intake valve** moves up and down to open or close the intake port to allow the air/fuel mixture into the cylinders.



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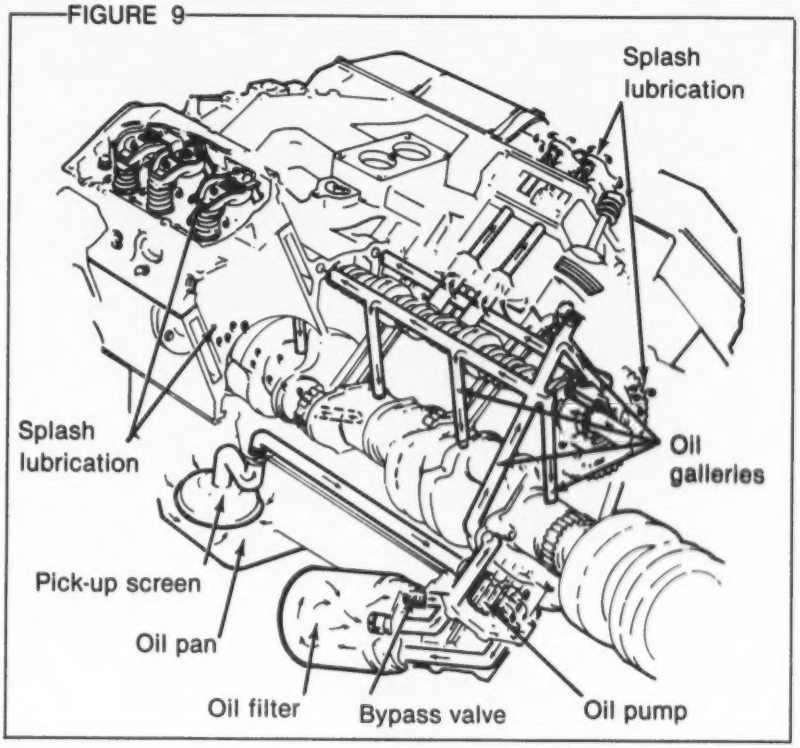
Engine lubrication system (Figure 9)

- Reduces friction by providing lubrication around and between moving parts or contact points within engine
- Helps transfer heat to cool engine
- Cleans engine by removing contaminants

EXAMPLE:

FIGURE 9



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How Often Do I Change the Oil?

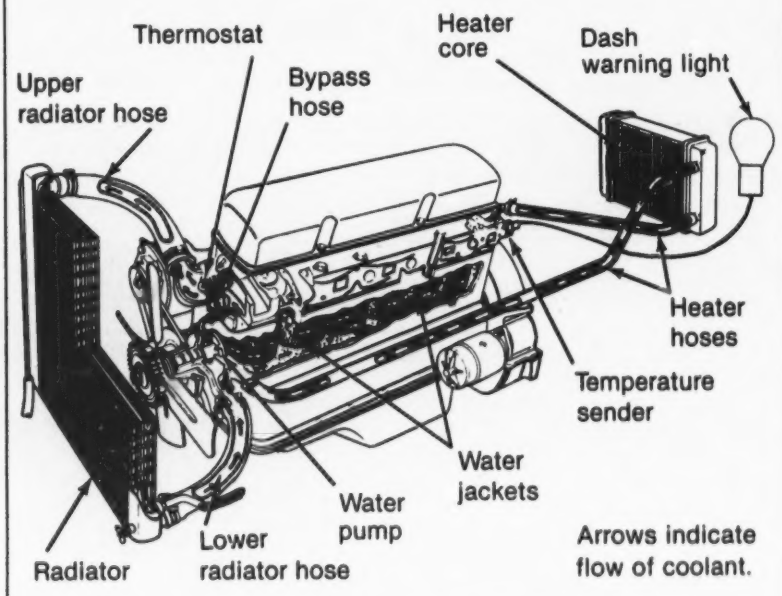
It's hard to know just how often to change the oil. As a general rule, you need to consult a service manual to determine the manufacturer's recommendations for required oil changes, but keep in mind that driving conditions—driving in extremely dusty areas or stop-and-go city driving—can reduce the time between oil changes. Also remember to change the oil filter when you change the oil. Consult the manufacturer's recommendations to determine just how often to change the filter.

Engine cooling system (Figure 10)

- Circulates air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage

EXAMPLE:

FIGURE 10



Liquid-type cooling system

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It Keeps the Temperature Down!

The average temperature inside an engine's combustion chamber is approximately 2000°F—hot enough to melt the pistons, warp the cylinder block, and ruin the engine oil. A liquid-type cooling system keeps the temperature down by circulating liquid around the combustion area and by transferring the heat in the liquid to the air that flows through the radiator. Approximately one-third of the heat of combustion is transferred away from the engine parts in this way.

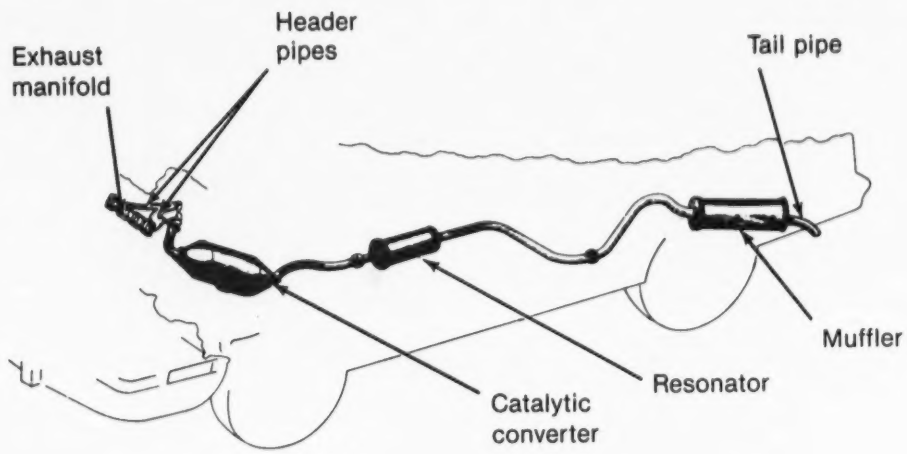
Exhaust system

- Reduces noise caused by the combustion process within the engine
- Directs harmful gases and heat away from engine

The Exhaust System: It Gets Rid of Harmful Gases and Reduces the Noise

The basic exhaust system consists of an exhaust manifold, header pipes, catalytic converter(s), muffler, and tail pipe. These parts work together to quiet the noise produced by engine combustion and to carry away the exhaust gases to be released into the atmosphere at the rear of the vehicle.

There are two basic types of exhaust systems: single and dual. Single systems (see the drawing below) have only one pathway to carry exhaust gases, while dual systems have two separate exhaust pathways.



Single exhaust system

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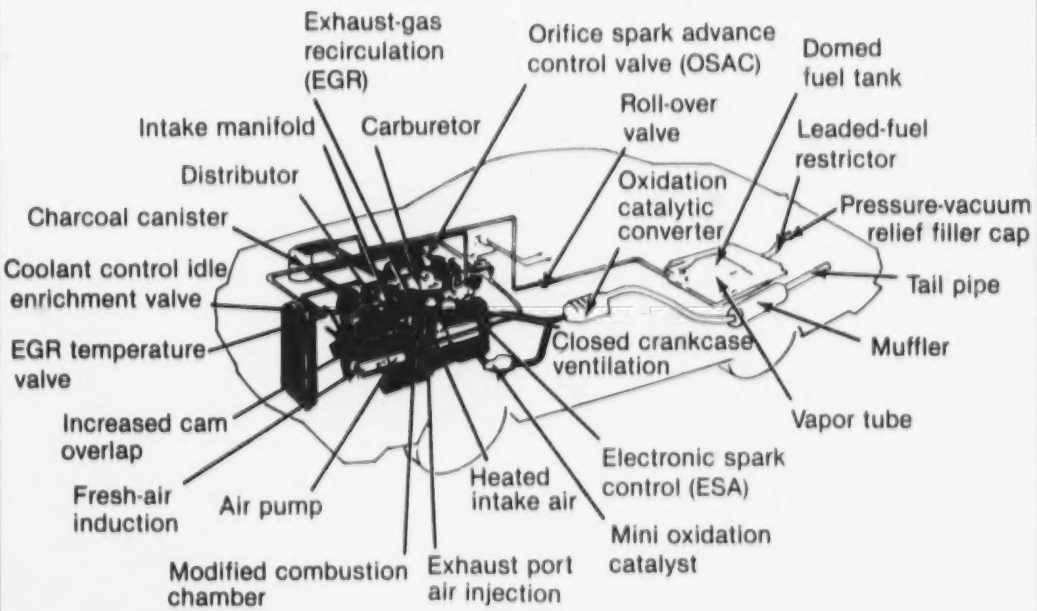
Emission-control system

- Promotes clean, efficient burning of fuel mixture within combustion chamber
- Helps exhaust gases continue burning process as they move through exhaust system
- Minimizes escape of harmful vapors from carburetor, fuel tank, fuel cap, and crankcase

Looks Complicated, But It's Really Important

In the pre-emission-control spark-ignition engine, gasoline was mixed with air to produce a combustible mixture. However, when the mixture burned, complete combustion never took place—some polluting gases always came out the tail pipe and escaped into the atmosphere. These gases combined with the gases from many other vehicles to form smog. Smog is unhealthy to breathe. To help control smog, federal and state laws were enacted that require manufacturers to install emission-control devices (smog-control devices) on their vehicles. Although it is a complicated system (see the illustration below), the emission-control system makes our country a healthier place in which to live.



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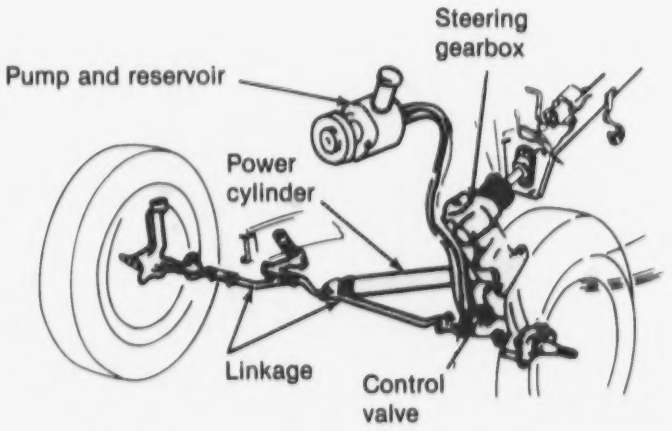
Steering system

- Allows driver to turn front wheels right or left to control vehicle direction
- Transmits road feel to driver's hands

The Steering Wheel's Connected to the Steering Shaft . . .

The steering system consists of a series of gears, swivel joints, and rods used to turn the front wheels left or right. The driver's turning the steering wheel turns the shaft that turns a steering gear that moves the tie rods that move the wheels.

There are two basic types of steering systems: linkage (worm-gear) and rack-and-pinion. A linkage-type system is illustrated below.



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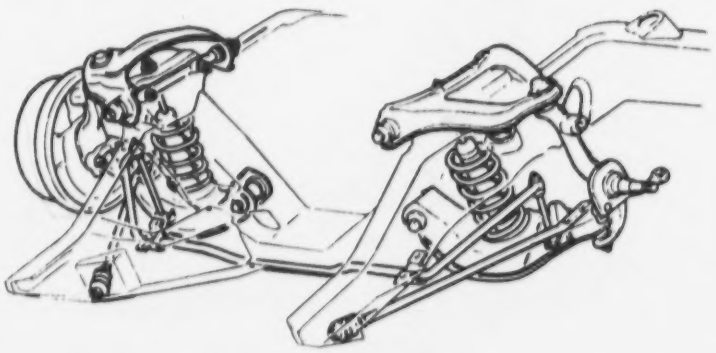
Suspension system

- Absorbs road shock that results from wheels hitting holes or bumps
- Allows cornering without extreme body roll

What Puts the Spring in the Suspension System?

The main parts of the suspension system are the front and rear springs. Seem simple enough? Well, to make things a little more complicated, there are four basic types of springs used in conventional systems: coil springs, leaf springs, torsion bars, and air springs. To make things even more complicated, many vehicles have different types of springs at the front and rear. Coil and leaf springs are used on both front and rear suspension assemblies, torsion bars are used only on front assemblies, and air springs are used either to replace or assist conventional springs at either the front or rear assembly. And if that's not complicated enough, there are also new air-suspension systems that are being used to replace conventional systems.



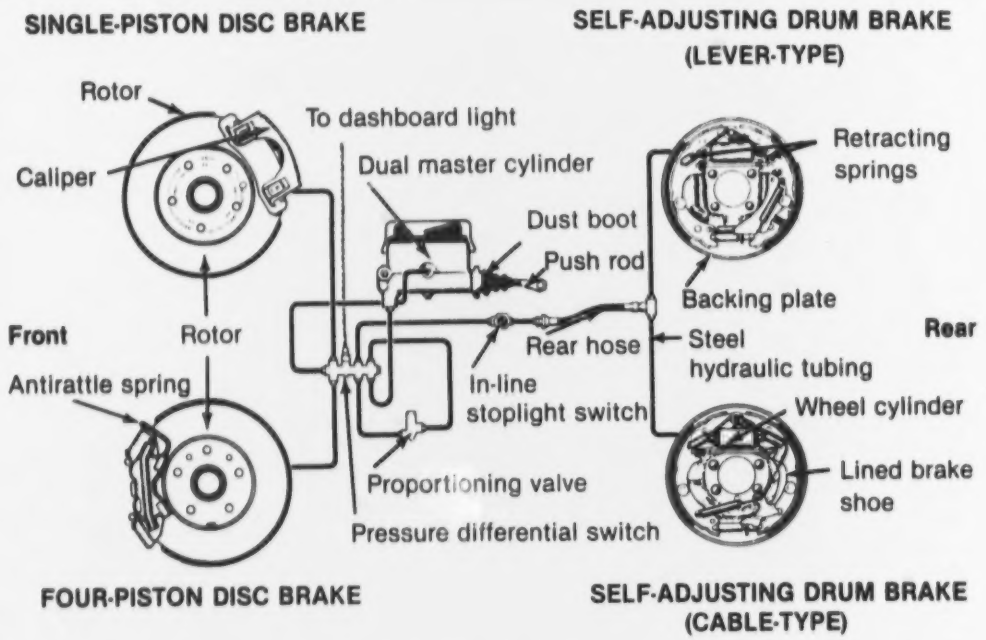
Used with permission of General Motors Corporation.

Brake system (Figure 11)

- Allows driver to reduce speed of or stop moving vehicle
- Holds vehicle stationary when parked

EXAMPLE:

FIGURE 11



Four different brake designs are illustrated. In practice, brakes are paired, front or rear.

Used with permission of Raybestos/Brake Systems Inc.

Slow Down, Partner . . .

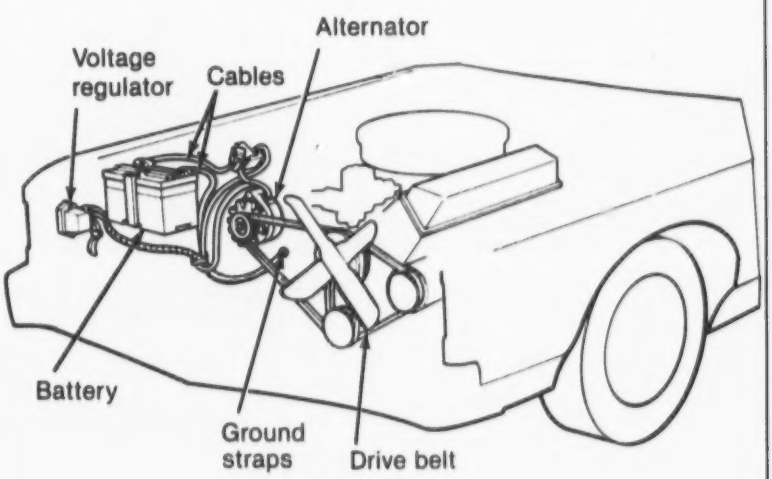
Brakes are devices that use friction to slow down, stop, or hold a vehicle in place. To slow down or stop a vehicle, the driver applies pressure to the brake pedal, which causes a control device to force the brake shoes (or pads) against the rotating brake drums (or discs). To hold the vehicle in place, the driver activates the parking brake, which pulls a steel cable that pulls a lever inside the drum- or disc-brake assembly. The action of the lever forces the brake lining against the rear drums (or discs).

Charging system (Figure 12)

- Produces, controls, and monitors electrical current needed while vehicle is running

EXAMPLE:

FIGURE 12



Used with permission of Chrysler Corporation.

The Charging System: What Does the Work?

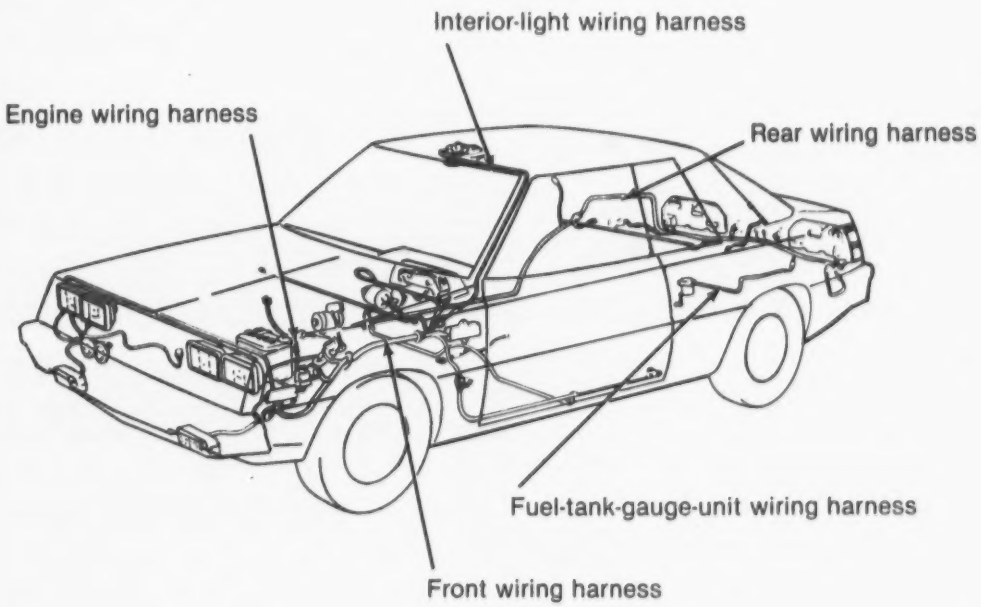
The two workhorses of the charging system are the alternator and the voltage regulator. The alternator makes electricity when a magnetic field moves over a coil of wire. When the engine is running, the alternator supplies the vehicle's electrical needs and recharges the battery. The regulator keeps the battery from becoming overcharged because the alternator can produce more electricity than the battery needs.

Chassis electrical system

- Powers safety and warning devices, convenience accessories, and lights

Harnessing Light

The chassis electrical system includes the headlights, parking lights, turn signals, stop lights, backup lights, taillights, and interior lights (instrument-panel lights, warning lights, and overhead and courtesy lights). These various components are connected with many different kinds of wires, most of which are collected into harnesses to enable easy installation at the factory. See the major harness assemblies in the illustration below.



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Heating and air-conditioning system

- Heats outside air and circulates heated air into passenger compartment (Figure 13-a)
- Pulls warm air from passenger compartment to be cooled, dehumidified, and cleaned, and then returns air back to passenger compartment (Figure 13-b)

EXAMPLE:

FIGURE 13

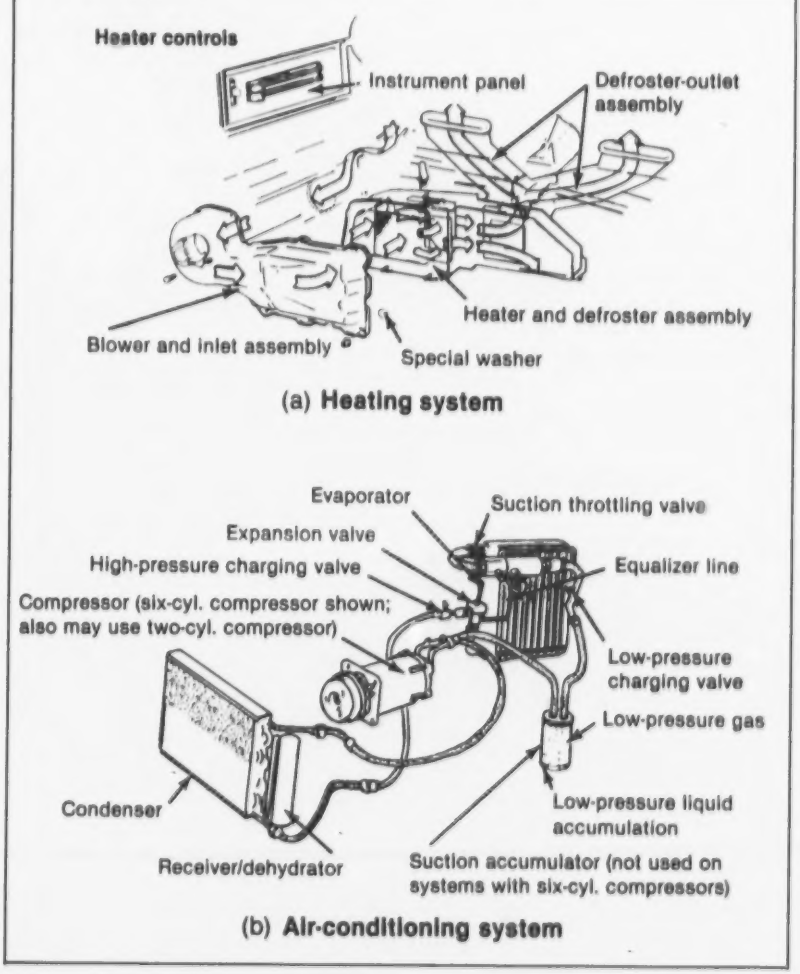


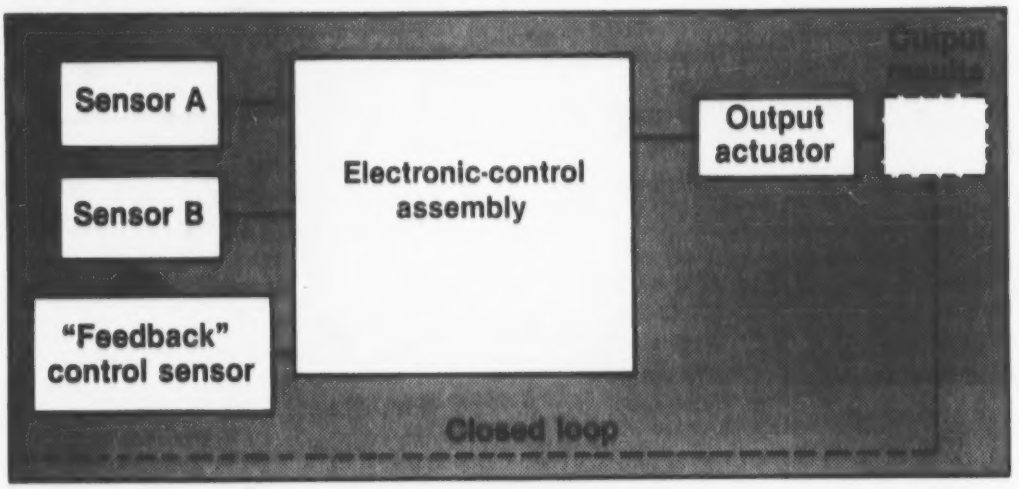
Illustration *a* used with permission of Chevrolet Motor Division, General Motors Corporation. Illustration *b* used with permission of Ford Motor Company.

Computer-control system

- Electronically monitors operation of various systems and adjusts those systems or provides driver or service person with information about those systems

The Key to Accurate Systems' Control

As you have seen, many vehicle systems (starting, ignition, fuel, exhaust, etc.) have become increasingly complex in design, and new systems (emission control, for example) have also been added to meet certain vehicle requirements. Designing more complex systems and increasing their number have created the need for yet another system—one to monitor and coordinate other systems in order to maximize vehicle performance. The electronic-control system is the key to meeting this need, and the computer is the key to the electronic-control system. The electronic sensors in the vehicle systems send signals to the computer. The computer analyzes these signals and then sends messages back to activate or deactivate system components to provide the most accurate performance from the vehicle's systems.



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STUDY AUTOMOTIVE DESIGN

SUPPLEMENT 1

Checksheet for Recording Vehicle Fluid Levels

Procedure	Fluid level		
	Too high	At proper level	Too low
Check engine-oil level			
Check coolant level			
Check steering-fluid level			
Check transmission-fluid level			
Check brake-fluid level			
Check windshield-washer-fluid level			

SUPPLEMENT 2

Vehicle Lighting-Equipment Requirements

- Passenger vehicles, pickups, panel trucks, buses, and trucks less than 80 inches in overall width (See Figure 1 on the following page.)*

1. Beam indicator
2. Two red tail lamps

   NOTE: Only one tail lamp is required on vehicles manufactured before September 30, 1961.

3. Two red to amber stop lamps

   NOTE: Only one stop lamp is required on vehicles manufactured before September 30, 1961.

4. One white license-plate lamp

   NOTE: Commercial-type trucks with license attached to front bumper are not required to have a light shining on the tag.

5. Two red reflectors

   NOTE: Reflectors may be incorporated as part of the tail lamp. Only one reflector is required on vehicles manufactured before September 30, 1961.

6. Turn signals

   a. Two white to amber front turn signals

   b. Two red to amber rear turn signals

   NOTE: Turn signals are not required on vehicles manufactured before September 30, 1961, except in the following cases: any vehicle or combination of vehicles 80 inches or more in overall width; or 14 feet or more in length measured from the top of the steering wheel to the rear extremity of the vehicle or combination of vehicles; or when the distance from the top of the steering post to the left outside limit of the body, cab, or load exceeds 24 inches.

*See Section 2-1 of the Oklahoma rules and regulation manual for requirements on vehicles not listed in this supplement.

7. Two to four white head lamps, depending on lamp type (sealed-beam or replacement-bulb)

   a. Sealed-beam head lamps

      (1) 5 3/4-inch-diameter dual upper beam, type 1 or 1C1; lower beam, type 2 or 2C1

      (2) 7-inch-diameter single, both upper and lower beam (most are type 2 or 2D1)

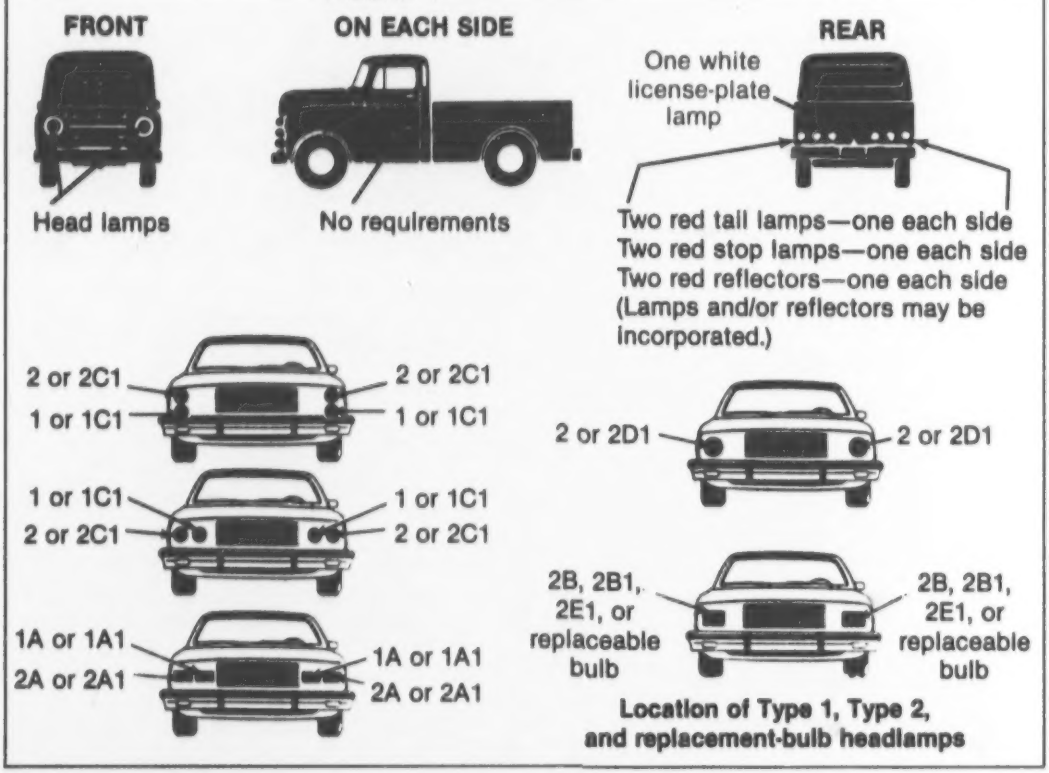
      (3) 6 1/2-×-4 1/4-inch rectangular dual upper beam, type 1A or 1A1; lower beam type 2A or 2A1

      (4) 200-mm-×-142-mm (about 8-×-5-inch) rectangular single, both upper and lower beam, type 2B or 2B1

      (5) 6 1/2-×-4 1/2-inch rectangular single, both upper and lower beam, type 2E1

   b. Replacement-bulb head lamps—both upper and lower beam, single standard-size halogen bulb

FIGURE 1



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SUPPLEMENT 3

Standard Glazing-Material Codes and Terms

All approved safety glazing materials are now marked with the words AMERICAN STANDARD, or the letters AS, followed by a number indicating the positions in which the material may be used in a vehicle. The inspector must be familiar with these numbers to complete the inspection procedure. Glazing materials bearing the following identification may be used in the locations designated below.

Codes

- AS-1 — Laminated safety glass marked AS-1 is required in windshields and is acceptable in any glazing material in a vehicle.
- AS-14 — Laminated safety glass marked AS-14 is required in windshields and is acceptable in any glazing material in a vehicle.
- AS-2 — Laminated or tempered safety glass marked AS-2 is acceptable for use in any glazing material in a vehicle *except* the windshield.
- AS-3 — Laminated or tempered safety glass marked AS-3 is acceptable in any glazing material on school buses *except* in the windshield and the side windows to the immediate right and left of the driver's location.
- AS-4 and AS-5 — Rigid plastic safety glazing material marked AS-4 and AS-5 is acceptable in any glazing material on school buses *except* windshields and side windows to the right or left of the driver's location.
- AS-6 and AS-7 — Flexible plastic safety glazing material is acceptable for use in rear windows of soft tops, flexible curtains, or readily removable windows.
- AS-8 and AS-9 — Wire glass marked AS-8 and AS-9 is acceptable for use in folding doors, standee and rearmost windows in buses, or windows to the rear of the driver in trucks and truck tractors.

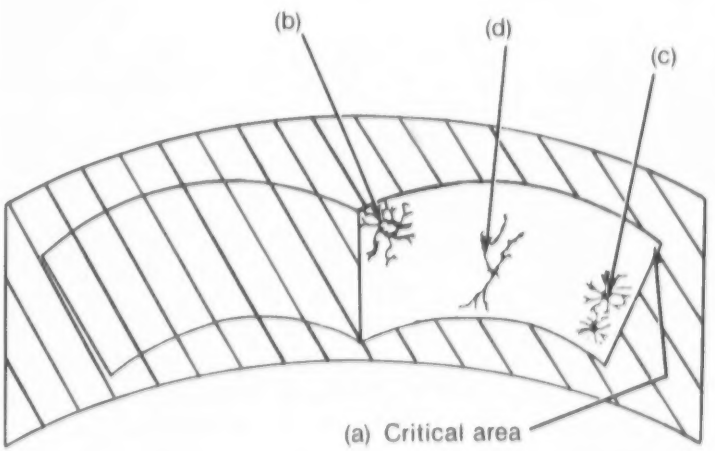
Terms

The inspector must also know the definitions of the following terms in order to conduct the inspection of the windshield and other glazing materials.

- Critical area — The area cleaned by the normal sweep of the windshield-wiper blade on the driver's side. See Figure 1-a.

- Outright breakage — Severely cracked or shattered glazing material damaged to the extent that air passes through it, or that it can be moved by running a fingertip over the cracked area, or that it feels sharp when running a fingertip over the cracked area. See Figure 1-b.
- Star breakage (shot damage) — Vented breaks with cracks radiating from the point of impact. See Figure 1-c.
- Strain (hairline) cracks — Cracks with no point of impact. See Figure 1-d.

FIGURE 1



Student Supplement 3 adapted with permission of the Motor Vehicle Inspection Division, Oklahoma Department of Public Safety, from *Oklahoma Official Motor Vehicle Emission and Mechanical Inspection Rules and Regulations Manual*, copyright ©1985.

SUPPLEMENT 4

Checksheet for Recording Results of Vehicle Safety Inspection

Directions: Completely fill out vehicle information requested and then check appropriate column for each of the vehicle areas listed below. If vehicle is rejected in any area of the inspection, fill out the comment section by describing reason for rejection.

Vehicle information

License number _____ State _____

Make _____ Model _____

Year _____ Mileage reading _____

Results of vehicle safety inspection

	Pass	Reject
Brake system		
• Failure-indicator-lamp function	_____	_____
• Service-brake performance	_____	_____
• Brake-system integrity	_____	_____
• Brake-pedal reserve	_____	_____
• Brake power-unit function (if vehicle is so equipped)	_____	_____
• Visual inspection	_____	_____
• Parking-brake function	_____	_____

Comments _____

_____

_____

_____

_____

	Pass	Reject
Wheels and tires		
• Wheel inspection	_____	_____
• Tire inspection	_____	_____

Comments _____

_____

_____

_____

_____

_____

	Pass	Reject
Exhaust system		
• Visual inspection	_____	_____

Comments _____

_____

_____

_____

_____

_____

	Pass	Reject
Steering system		
• Jamming inspection	_____	_____
• Steering-wheel-lash inspection	_____	_____

Comments _____

_____

_____

_____

_____

	Pass	Reject
Suspension system		
• Visual inspection	_____	_____

Comments _____

_____

_____

_____

_____

	Pass	Reject
Lighting equipment		
• Headlight-switch function	_____	_____
• Dimmer-switch function	_____	_____
• Turn-signal-lever function	_____	_____
• Visual inspection	_____	_____
• Light function and color	_____	_____

Comments _____

_____

_____

_____

_____

	Pass	Reject
Windshield and glazing material		
• Windshield inspection	_____	_____
• Glazing-material inspection	_____	_____

Comments _____

_____

_____

_____

	Pass	Reject
Windshield wipers		
• Visual inspection	_____	_____
• Wiper-control function	_____	_____
• Wiper operation	_____	_____

Comments _____

_____

_____

_____

_____

_____

	Pass	Reject
Horn		
• Visual inspection	_____	_____
• Horn function	_____	_____

Comments _____

_____

_____

_____

_____

ASSIGNMENT SHEET 1	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 9

Apply guidelines for classifying vehicles according to their power-train design

Name _____ Score _____

INTRODUCTION

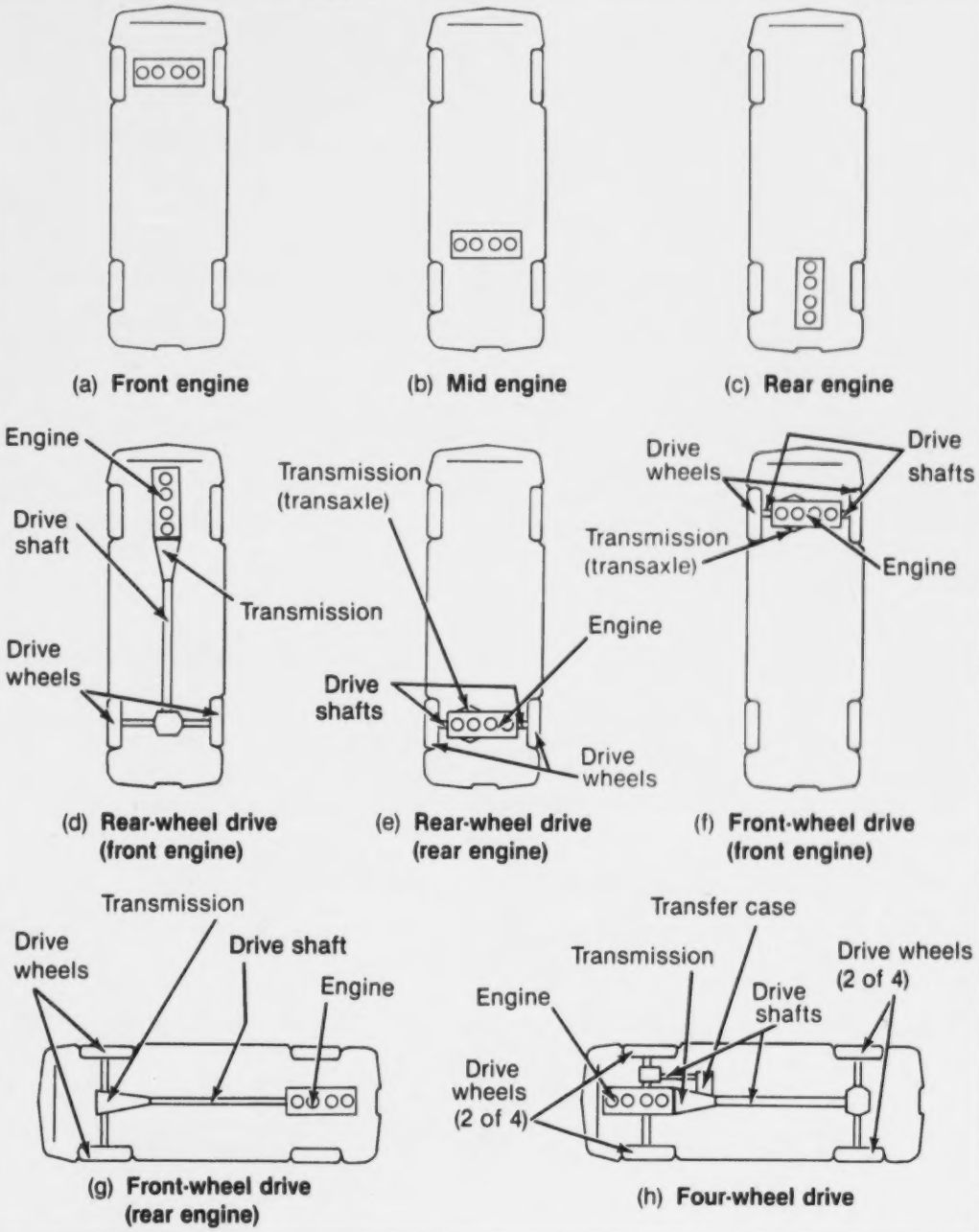
As you learned in the information sheet, a traditional power train consists of a front-mounted engine and a drivetrain assembly that includes a clutch (on vehicles with manual transmissions), transmission (either manual or automatic), universal joint, drive shaft, differential, and drive wheels. This traditional power-train design is called a front-engine, rear-wheel-drive type. See Figure 1-d on the following page. In the past, this power-train design was essentially the only one on the market, making the service specialist's job relatively easy. All he or she had to do was to become familiar with the operation of the power-train components and then trace the interrelated parts from the front to the back of the vehicle to determine where the system had broken down.

Today, however, several types of power-train designs are seen: front-engine with front-wheel drive, mid-engine with rear-wheel drive, rear-engine with rear-wheel drive, front-engine with four-wheel drive, etc. So many designs complicate power-train service, but it is important that the service specialist be able to recognize the various power-train designs because they require varying service procedures for the vehicles as well as varying operating recommendations for the customers. How can the service specialist recognize what type of power train he or she is working with? The following guidelines should help.

The two factors influencing power-train design are the location of the engine and the design of the drivetrain.

- Engines may be located in the front, middle, or rear of a vehicle. See Figure 1-a, b, and c.
- There are three types of drivetrain designs: rear-wheel drive, front-wheel drive, and four-wheel drive. See Figure 1-d, e, f, g, and h.

FIGURE 1


(a) Front engine
(b) Mid engine
(c) Rear engine
Engine
Drive shaft
Transmission
Drive wheels
(d) Rear-wheel drive (front engine)
Transmission (transaxle)
Engine
Drive shafts
Drive wheels
(e) Rear-wheel drive (rear engine)
Drive wheels
Drive shafts
Transmission (transaxle)
Engine
(f) Front-wheel drive (front engine)
Transmission
Drive wheels
Drive shaft
Engine
(g) Front-wheel drive (rear engine)
Transfer case
Transmission
Drive wheels (2 of 4)
Engine
Drive shafts
Drive wheels (2 of 4)
(h) Four-wheel drive

580

Engine location. The location of the engine influences how the vehicle handles. The engine accounts for much of the weight of a vehicle and this weight is concentrated in a rather small area. For this reason, many design experts say that the best place to locate the engine is in the middle of the vehicle. Doing so allows the weight to be distributed over a wider area of the vehicle as it moves, turns, accelerates, and stops. By distributing the weight over a greater area, the changes in force acting on the vehicle in motion are less noticeable.

However, it is not always convenient to place the engine in the middle of the vehicle. Such placement reduces the amount of passenger space and affects other design possibilities and access to the engine. For these reasons, the use of mid-engine designs is usually limited to two-passenger sports cars and some trucks. Most other vehicles will have either a front or rear engine, but even this choice is influenced by the fact that so much of the weight of the vehicle is concentrated in the engine.

This concentration of weight can be used to an advantage. If a vehicle is built with a heavier load over the drive wheels, it will have more *traction*. Traction is the measure of how well the vehicle's wheels grip the road. Good traction prevents the vehicle from slipping as much when the roads are slick from water, ice, snow, oil, and other conditions. The vehicle designer can improve the vehicle's traction by placing the engine over the drive wheels. Thus, a front-engine design should have front-wheel drive and a rear-engine design should have rear-wheel drive for best traction.

Drivetrain design. For many years, most vehicles were built with front engines and rear-wheel drive even though this design is not the best in terms of traction. However, when one considers the components of a drivetrain, the reason for using this design becomes more apparent. The purpose of the drivetrain is to transfer power from the engine to the drive wheels. To accomplish this, three major components are used: drive shafts, a transmission, and a differential. Although the placement and exact design of these components will vary with particular drivetrain designs and individual vehicles, their functions are essentially the same in each vehicle.

Drive shafts and axles — Connect the components of the drivetrain to each other and to the engine and drive wheels.

Transmission — Uses gears to allow the change of rotation of the drive wheels between forward and reverse and to change the speed of rotation of the drive shafts to get the most efficient use of power from the engine.

Differential — Uses gears to allow the drive wheels to turn at different speeds when the vehicle is turning or one wheel has more traction than the other, such as when one is stuck in mud.

As you can see, drivetrain designs must fulfill several purposes. A few years ago when the emphasis was on big, powerful engines, there was not enough room in the engine compartment to build front-wheel drive vehicles. This was due in part to the space requirements of the engine and drivetrain but also resulted from the heavy suspension systems and steering systems such large engines required.

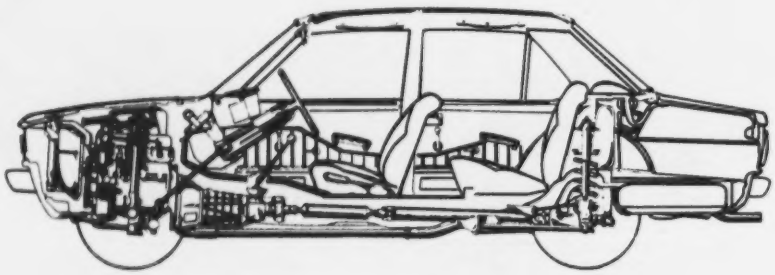
When smaller, lighter cars gained popularity and the emphasis shifted to fuel economy, smaller engines were more widely used. This permitted down-sizing of the suspension and steering systems, and allowed more room for drivetrain components. Thus, today's vehicles are designed primarily with front engines and front-wheel drive.

Four-wheel drive has also become more popular with today's drivers. At one time, four-wheel drive was limited to trucks and special vehicles such as Jeeps. Today, many cars and light trucks offer four-wheel drive as either a standard design feature or as optional equipment. The use of four-wheel drive allows even more traction than either front- or rear-wheel drive alone.

Four-wheel drive requires an additional component in the drivetrain called a *transfer case*, along with additional drive shafts and a second differential. The transfer case directs some of the power of the engine to the second set of drive wheels. Four-wheel drive may be either *full-time* or *part-time*. With full-time four-wheel drive, all four wheels are always acting as drive wheels. In the part-time design, the driver can choose whether the vehicle is in two-wheel or four-wheel drive. To change the number of drive wheels, the driver may need to simply shift a lever or he or she may also have to turn discs on the wheel hubs that lock the wheels to the drive axles.

DIRECTIONS

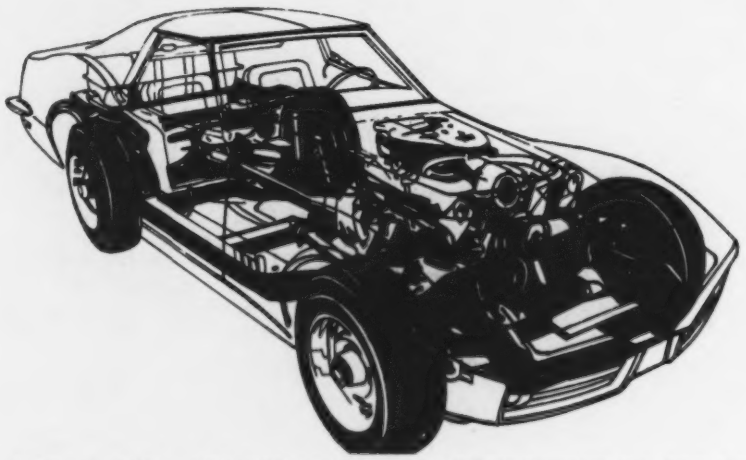
Study the following illustrations of vehicles and determine the power-train design in each. In the spaces provided, write whether the engine is located in front, middle, or rear of the vehicle and whether the drivetrain is a front-, rear-, or four-wheel-drive design.



Used with permission of Fiat.

1. **Engine location** _____

   Drivetrain design _____



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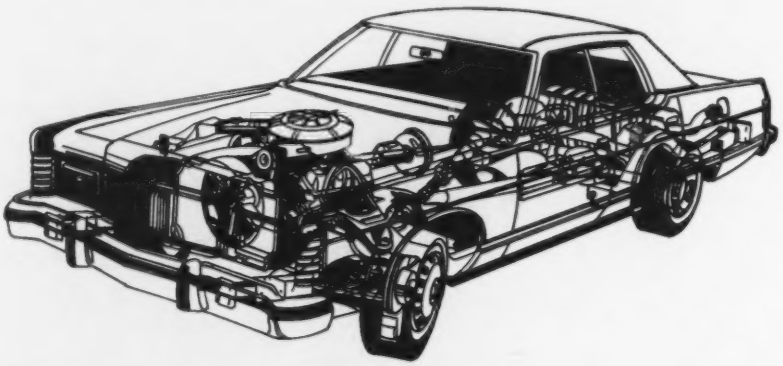
2. **Engine location** _____

   Drivetrain design _____

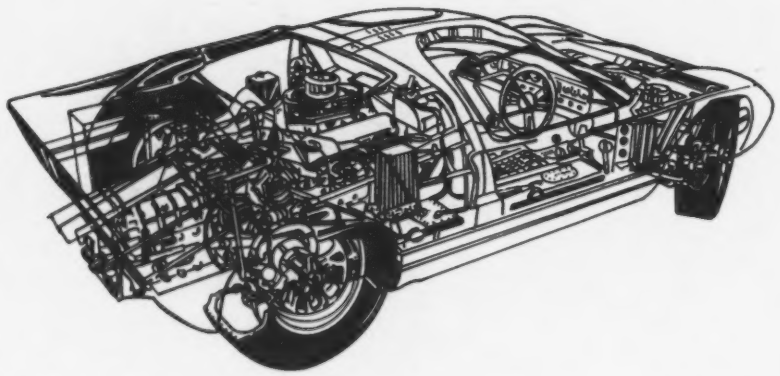


Used with permission of Ford Motor Company.

3. **Engine location** _____

   Drivetrain design _____

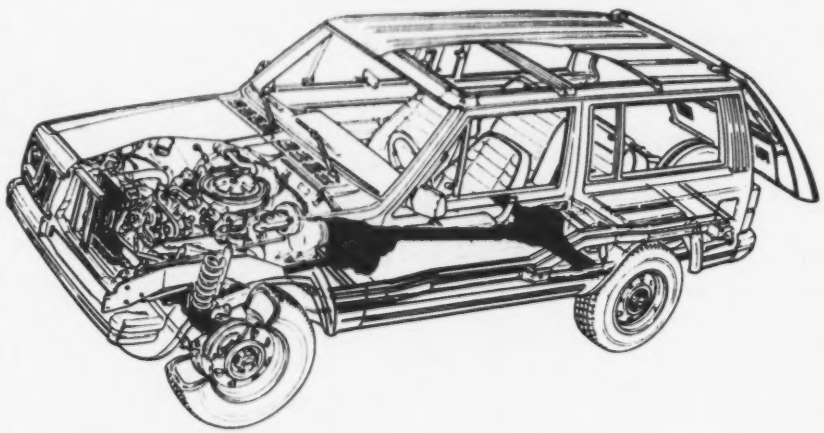
584



Used with permission of American Iron and Steel Institute.

4. **Engine location** _____

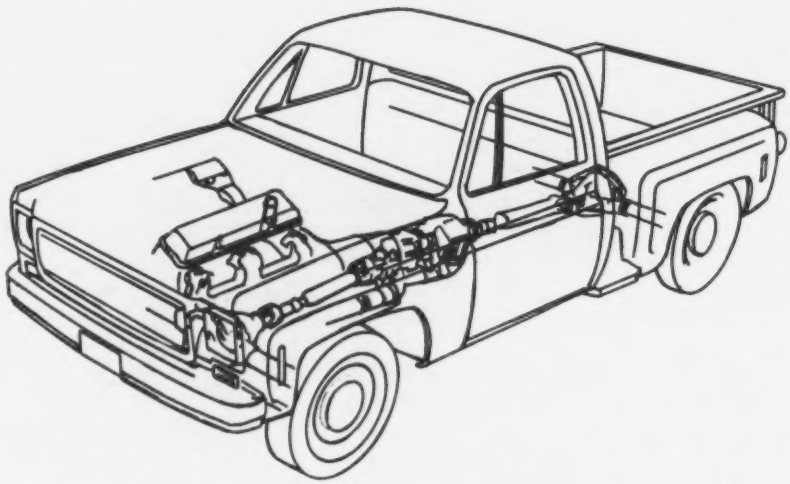
   Drivetrain design _____



Used with permission of American Motors Corporation.

5. **Engine location** _____

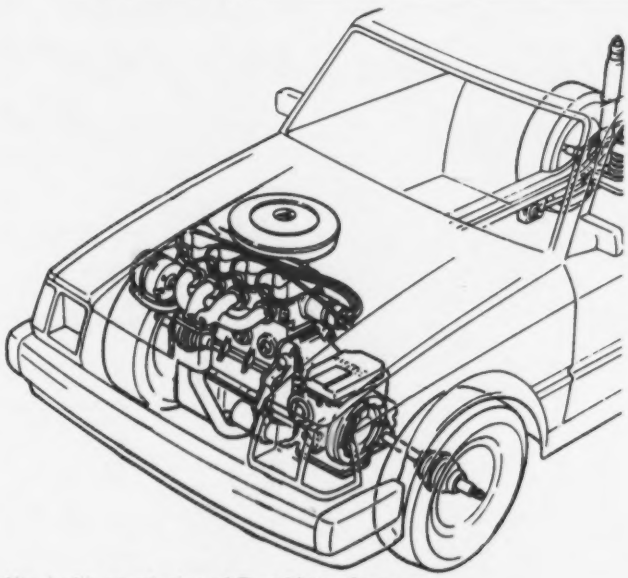
   Drivetrain design _____



Used with permission of Chevrolet Division, General Motors Corporation.

6. **Engine location** _____

   Drivetrain design _____



Used with permission of Ford Motor Company.

7. **Engine location** _____

   Drivetrain design _____

ASSIGNMENT ANSWERS	STUDY AUTOMOTIVE DESIGN

ASSIGNMENT SHEET 1

1. **Engine location** — Front
   Drivetrain design — Rear-wheel-drive
2. **Engine location** — Front
   Drivetrain design — Rear-wheel-drive
3. **Engine location** — Front
   Drivetrain design — Rear-wheel-drive
4. **Engine location** — Middle
   Drivetrain design — Rear-wheel-drive
5. **Engine location** — Front
   Drivetrain design — Four-wheel-drive
6. **Engine location** — Front
   Drivetrain design — Front-wheel-drive
7. **Engine location** — Front
   Drivetrain design — Front-wheel-drive

ACTIVITY SHEETS

STUDY AUTOMOTIVE DESIGN

ACTIVITY SHEET 1

Design a vehicle

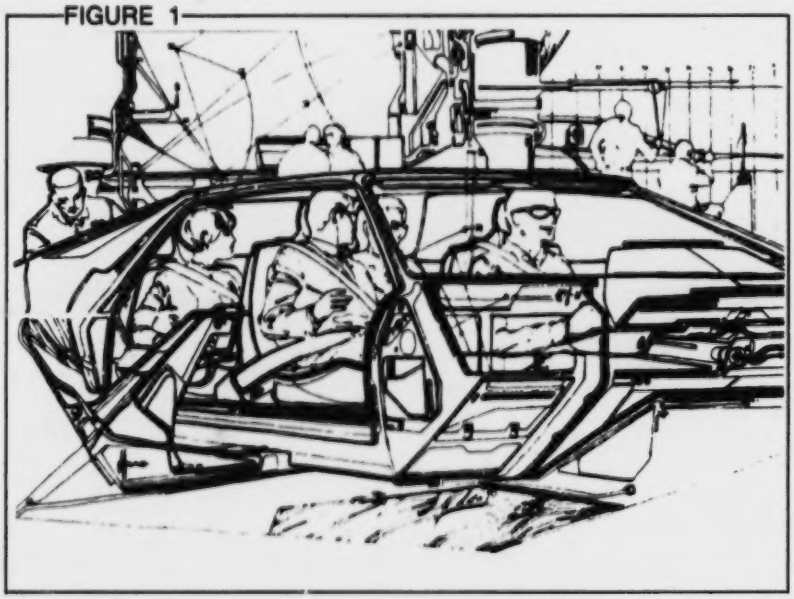
Name _____

INTRODUCTION

An automotive vehicle can have more than 4000 individual parts. Each part must be designed properly in order to function properly. If any part is not properly designed and does not function properly, the vehicle cannot function properly. Therefore, can you imagine what the results would be if automotive vehicles were not well designed and tested before being mass-produced? We would undoubtedly have ugly vehicles, very dangerous vehicles, and vehicles too expensive for most people to purchase.

Vehicle manufacturers start with drawings and ideas on paper (see Figure 1 below). Then they refine their ideas and build a prototype. Next, they build a mock-up model scaled to actual size. And finally, after everything checks out, they mass-produce the final vehicle. Many years of planning and testing go into each year's new-model vehicles. Many components are designed separately and these designs are built and tested and then modified so that they work together properly.

FIGURE 1



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Haven't you secretly dreamed about designing your own vehicle? In this activity sheet, you will have a chance to do so. When designing your vehicle, give careful consideration to the various types of vehicle styles, sizes, and major systems.

DIRECTIONS

Using drawing paper, design a vehicle. You may want to look at different designs that are featured in automotive magazines. You should also think about the following design considerations as you begin:

- Front-wheel drive vs. rear-wheel drive
- Fuel economy
- Number of passengers or other types of cargo to be carried
- Engine size and location
- Drive-axle location
- Passenger comfort
- Type of fuel to be burned
- Body shape

Keep in mind that this activity sheet is meant to be fun, so please feel free to be as creative as possible. Be ready to explain why you chose a particular design. Drawing ability is not as important as the ideas you have and the planning you do. Sketch the vehicle as best you can and write descriptions of design features, especially those that are not shown in the sketch.

JOB SHEET 1	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 7

Clean an engine

INTRODUCTION

Many vehicle owners never bother to remove the dirt and grime that builds up on their vehicle's engine; however, there are good reasons for cleaning the engine. Engines are made of metal and are dependent on rubber hoses, gaskets, and wiring for proper operation. Grease, oil, gasoline, and dirt make up the grime that can cause rust to form on metal and can deteriorate rubber parts and wiring. Also a buildup of grime can cause the engine to run hotter than normal, causing the cooling and lubrication systems to have to work harder to maintain proper operating temperature.

Cleaning an engine inside the vehicle is accomplished with a cleaning-solvent chemical and either a hot high-pressure water washing or a steam cleaning. Cleaning-solvent chemicals may be either brushed on the engine or sprayed on. In hot high-pressure water washings, water is heated from 190°F to 210°F, pressurized, and mixed with soap to float away the grime and solvent. With steam cleaning, water is super heated, pressurized from 150 psi to 250 psi, and sometimes mixed with a caustic soap to get rid of the grime. Whichever method is used, the technician must follow strict safety precautions to prevent injury to himself or herself and to the environment.

The Environmental Protection Agency, OSHA, and the state departments of safety have established guidelines concerning the residues of solvents and engine grime that result from engine cleanings. Cleaning must be done in a specially designated area that will provide for safe cleanup of these residues. Be familiar with these guidelines and follow them faithfully. Also, solvents, hot high-pressure cleaners and steam cleaners are all potentially dangerous. Solvents should **not** be breathed, and high-pressure cleaners and steam cleaners emit water hot enough to be dangerous unless these pieces of equipment are handled carefully. The manufacturer's instructions for operation of these machines must be followed faithfully.

EQUIPMENT AND MATERIALS

- Solvent/degreaser and manufacturer's instructions
- Steam cleaner or a hot high-pressure water cleaner and manufacturer's instructions
- Plastic bags
- Wire brush
- Carbon scraper
- Rubber apron, rubber gloves, and rubber overshoes
- Full face shield

PROCEDURE

1. Remove air cleaner from engine
2. Cover distributor and carburetor throat with plastic bags to keep solvent and water from entering them
3. Put on rubber gloves, apron, and overshoes
4. Put on face shield
5. Using carbon scraper, scrape heavily coated dirt and grease from engine
6. Apply cleaning solvent/degreaser to engine

   ► WARNING ◄

   Do **not** breathe vapors.

   CAUTION

   Do **not** allow chemical to get inside the alternator or starter; it can remove the insulation from the windings. Try **not** to get chemical spray near the distributor or the carburetor throat.
7. Allow solvent/degreaser to remain on engine for time prescribed by manufacturer

   NOTE: The chemical will only penetrate so far during the prescribed time. Reapply as necessary.
8. Using steam cleaner or high-pressure cleaner, clean inner surface of hood above engine and inner walls of vehicle's body as well as engine

   NOTE: Try **not** to spray near distributor or carburetor throat.
9. Turn off cleaner
10. Using carbon scraper, scrape any stubborn buildup on engine
11. Turn on cleaner and spot clean stubborn areas with steam or high-pressure water
12. Rinse entire engine
13. Turn off cleaner
14. Clean work area and properly dispose of waste materials
15. Properly store equipment and materials

JOB SHEET 2	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 10

Perform vehicle fluid-level checks

INTRODUCTION

Vehicle repair is becoming more complicated and more expensive each year. Vehicle owners are beginning to realize that periodic maintenance on their vehicles will save them both time and money in the long run. If you keep a customer's vehicle in top shape with routine maintenance, you will continue to get the customer's business when repair or maintenance work is needed. In short, the customer will want to come back to you and will trust your work.

The following are periodic maintenance procedures that will keep a vehicle running safely and smoothly. They consist of fluid-level checks that are critical to the proper operation of vehicle systems.

You are to read each of the guidelines below **before** performing these procedures. If not performed properly, some of these procedures are dangerous—dangerous to you or to the proper operation of the vehicle. Study the guidelines carefully and then perform the procedures. As a part of each procedure, you are to fill out the checksheet in Student Supplement 1.

Guidelines for checking engine-oil level

Engine oil is lost in three ways: some is burned during combustion, some is lost through leakage, and some is lost as a mist in the crankcase. To assure proper engine lubrication and operation, the engine oil must be maintained at the correct level. Therefore, the oil level must be checked at regular intervals—usually every time you fill the fuel tank.

- To check engine-oil level, an oil-level stick (dipstick) is used. The dipstick is located on the crankcase and protrudes down into the oil in the oil pan. The oil level is checked by withdrawing the dipstick and looking at the mark left by the oil on the stick. Oil is added only when the level on the dipstick is at or below the ADD OIL mark.

- When checking engine-oil level, the vehicle should be on level ground and the engine should not have been running for at least 10 minutes to allow the oil to drain back into the crankcase.

Guidelines for checking coolant level

An antifreeze-and-water solution is used as the coolant in a vehicle's cooling system. Low coolant level may result from leakage from the cooling system, causing engine overheating. Therefore coolant-level checks should be made regularly to keep the engine at proper operating temperatures.

- Checking the coolant level on most older vehicles involves removing the radiator cap on either a top- or side-mounted expansion tank. On this type of system, never under any circumstances attempt to remove the radiator cap when the engine is hot from running. The radiator cap itself will be extremely hot and a gusher of steam and hot coolant will squirt out of the radiator and scald you.

  Make sure the engine has cooled before opening the radiator cap. Test the system for coolness by squeezing the upper radiator hose with your hand; then if there is no pressure remaining in the radiator hose, it is safe to remove the radiator cap.

- Modern cooling systems have a coolant recovery system with the expansion reservoir connected to the radiator filler cap. The reservoir is always partially filled with coolant, even when the engine is cold. But when the coolant expands as the engine heats during operation, more coolant flows into the reservoir.

  On a system with a coolant recovery system, you visually check the coolant level in the expansion reservoir; the radiator cap is not removed with this type of cooling system. This visual check should be made when the engine is not running. Look at the marks on the outside of the reservoir. The reservoir usually has two marks: one shows where the level should be when the engine is hot; the other mark shows where the level should be when the engine is cold. Do not remove the cap on the reservoir itself.

Guidelines for checking steering-fluid level

Manual-steering system. Manual-steering systems require very little service other than a periodic check of the lubricant level in the steering gearbox. In this type of steering system, a filler plug at the top of the gearbox is removed and a visual check is performed to make sure the fluid level covers the gear (the fluid is level with the bottom of the plug hole).

Power-steering systems. Power-steering systems include a reservoir where the power-steering fluid is collected. Power-steering systems must be checked periodically to make sure the fluid is at the proper level in the reservoir. A dipstick on the reservoir is used for this purpose.

When checking the fluid level in the reservoir, make sure the engine is shut off but is still warm enough to give an accurate fluid reading on the dipstick.

Guidelines for checking automatic-transmission-fluid level

Maintenance of proper fluid level is critical to the operation of an automatic transmission. If the transmission fluid level is too low, the transmission pump takes in air, the fluid becomes spongy, and pressure builds up, causing delayed shifting and slipping and overheating and wearing of clutches and bands. If the fluid level is too high, the fluid foams, and the air in the foam causes the transmission to slip and overheat in much the same way as when the fluid level is too low. The fluid must be maintained at exact levels and checked periodically using the following guidelines during the check.

- The engine must be warmed to normal operating temperatures when the transmission fluid is checked. The fluid level will appear too low if checked when the engine is cold.
- The transmission must be in the correct selector position when the fluid is checked. The correct quadrant is usually in PARK or NEUTRAL, but this varies from vehicle to vehicle and the service manual should be consulted before the procedure is performed.

Guidelines for checking brake-fluid level

To maintain proper brake operation, the brake system should be inspected at the intervals recommended by the vehicle manufacturer—usually at least twice a year. Part of a complete brake inspection is checking the level of the brake fluid in the master cylinder.

There are two types of master cylinders on modern vehicles: diaphragm reservoirs and composite reservoirs. Procedures for checking the fluid level in these two types vary slightly because of the difference in the construction of the two types. But regardless of the master-cylinder construction, the following guidelines should be observed when conducting fluid-level checks.

- Brake fluid is poison; keep it away from your skin and eyes.
- Brake fluid will damage chrome and painted surfaces. Do not allow brake fluid to drip on these vehicle surfaces.
- Brake fluid is flammable. Keep it away from fire.

Guidelines for checking windshield-washer-fluid level

Many vehicles have a windshield washer as a component of the windshield-washer/wiper system. The windshield-washer component consists of a plastic reservoir for windshield-washer fluid, a motor, and a pump that forces the fluid through tubing to nozzles that spray the fluid onto the windshield to wash it. The windshield-washer fluid aids the windshield-wiper blades in cleaning the windshield. A properly cleaned windshield is one very important factor in safe driving—and often cannot be accomplished if the windshield-washer reservoir is empty. Checking the level of the windshield-washer fluid is therefore very important.

To check the fluid level in the reservoir only requires a visual inspection of the reservoir. The reservoir is made of translucent plastic, so you will usually be able to see the fluid level without removing the reservoir cover unless the location of the reservoir prevents this. The only precaution you need to take in this procedure is to make certain that you have located the windshield-washer reservoir. The coolant recovery system reservoir can be confused with the windshield-washer reservoir. Be sure you are checking the proper reservoir.

EQUIPMENT AND MATERIALS

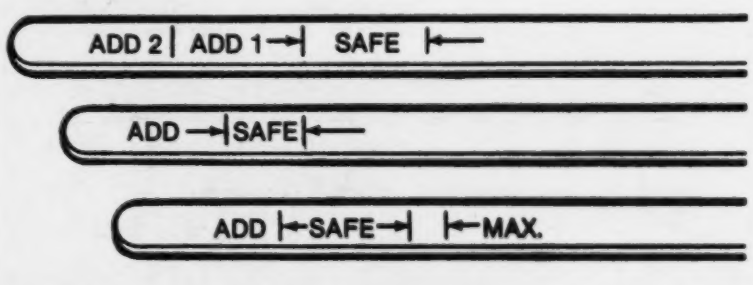
- Shop towels or paper towels
- Screwdriver
- Service manual for make and model of vehicle
- Student Supplement 1
- Pencil or pen

PROCEDURE

For checking engine-oil level

1. Drive vehicle onto level floor, shut engine off, and let vehicle stand for at least 10 minutes to allow oil to drain into crankcase
2. Locate engine-oil dipstick on crankcase
3. Remove engine-oil dipstick and wipe it clean
4. Reinsert dipstick into crankcase until securely seated
5. Withdraw dipstick again and check oil level: Oil should be maintained at a level within the SAFE zone just above the ADD mark (Figure 1)

FIGURE 1



Three typical dipsticks

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6. Record engine-oil level in proper place on checksheet

PROCEDURE

For checking coolant level on system without coolant recovery system

1. Shut engine off and let vehicle stand until engine cools

   NOTE: The engine should **not** be running when this check is performed.

2. Test to make sure engine has cooled: Squeeze upper hose with your hand (See Figure 2-a)

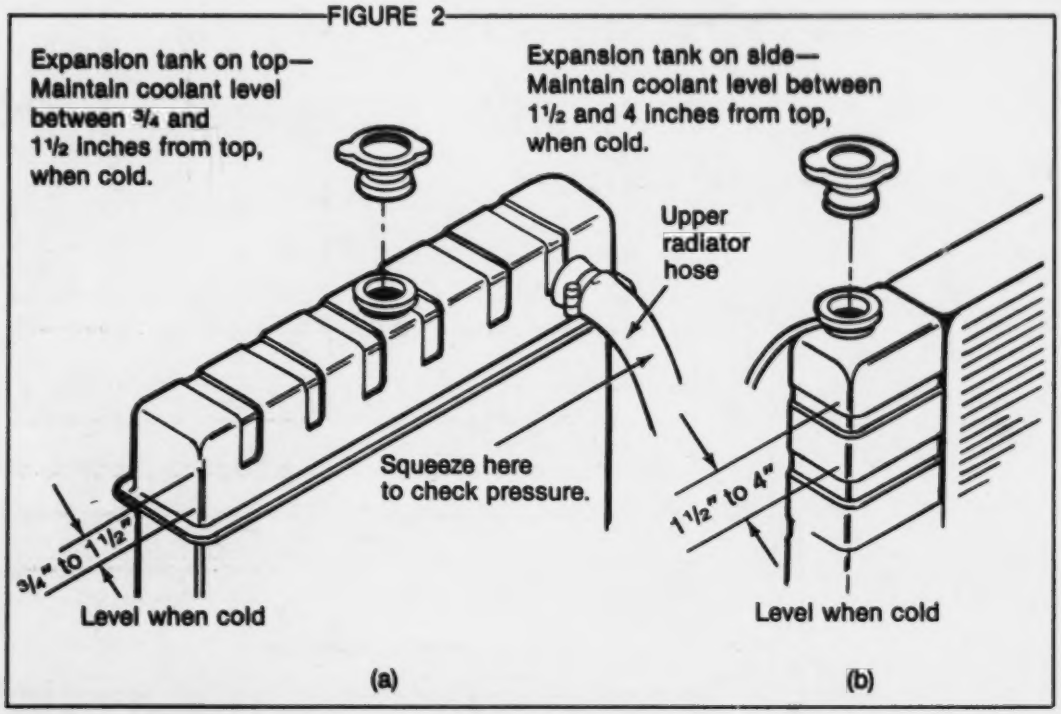
   ► WARNING ◄

   Never attempt to remove the radiator cap when the engine is hot. The radiator itself will be hot and a gusher of steam and hot coolant will squirt from the radiator.

3. *If* there is no pressure remaining in the radiator hose, remove the radiator cap very slowly and carefully

4. Check coolant level: On systems where the expansion tank is on top (see Figure 2-a), coolant level should be between ¾ and 1 ½ inches from the top; on systems where the expansion tank is on the side (see Figure 2-b), the coolant level should be between 1 ½ and 4 inches from the top

FIGURE 2



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5. Record coolant level in proper place on checksheet

PROCEDURE

For checking coolant level on system with coolant recovery system

NOTE: Most modern vehicles have a coolant recovery system.

1. Shut engine off

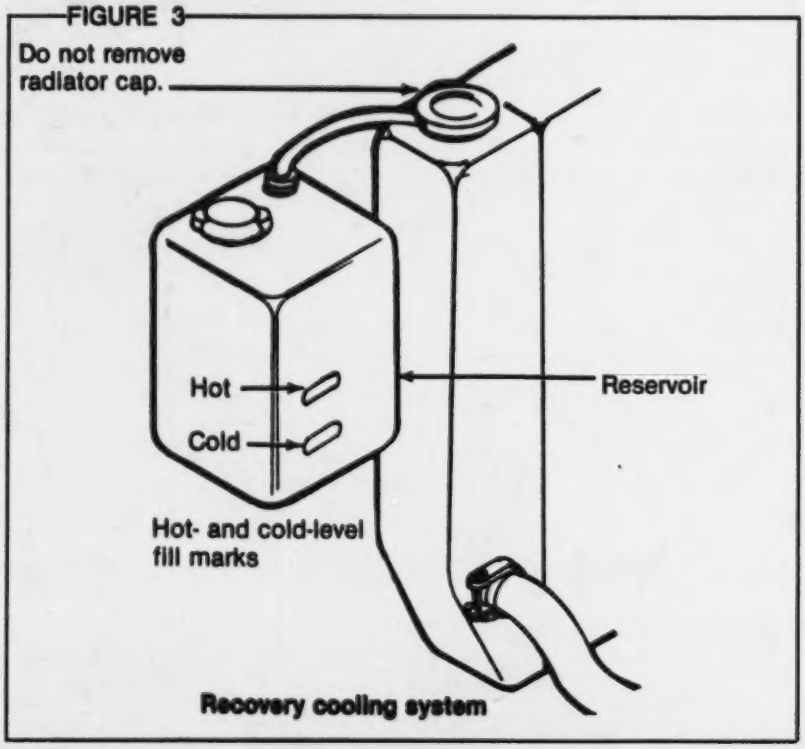
   NOTE: The engine should **not** be running when this check is performed, but the engine temperature is not as important as for a system without a recovery reservoir. With a recovery reservoir the engine may be hot or cold because the coolant reservoir has marks indicating proper coolant levels for either a hot or cold engine.

2. To check coolant level, look at hot- or cold-engine coolant-level mark to determine whether coolant is at proper level for engine temperature (See Figure 3)

   ► WARNING ◄

   Do **not** remove radiator cap; do **not** remove cap on reservoir.

FIGURE 3



Recovery cooling system

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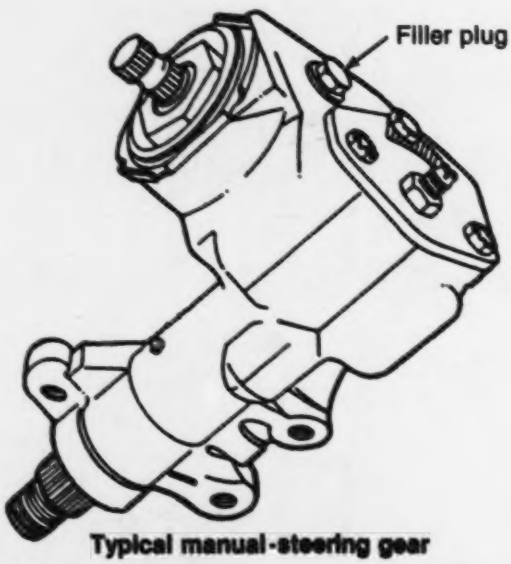
3. Record coolant level in proper place on checksheet

PROCEDURE

For checking fluid level on manual-steering system

1. Locate filler plug (See Figure 4)
2. Wipe housing around filler plug so dirt cannot fall into plug hole when plug is removed
3. Remove plug from housing (Figure 4)

FIGURE 4



Typical manual-steering gear

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4. Check fluid level: Fluid should be level with the bottom of the plug hole
5. Record fluid level on proper place on checksheet

PROCEDURE

For checking fluid level on power-steering system

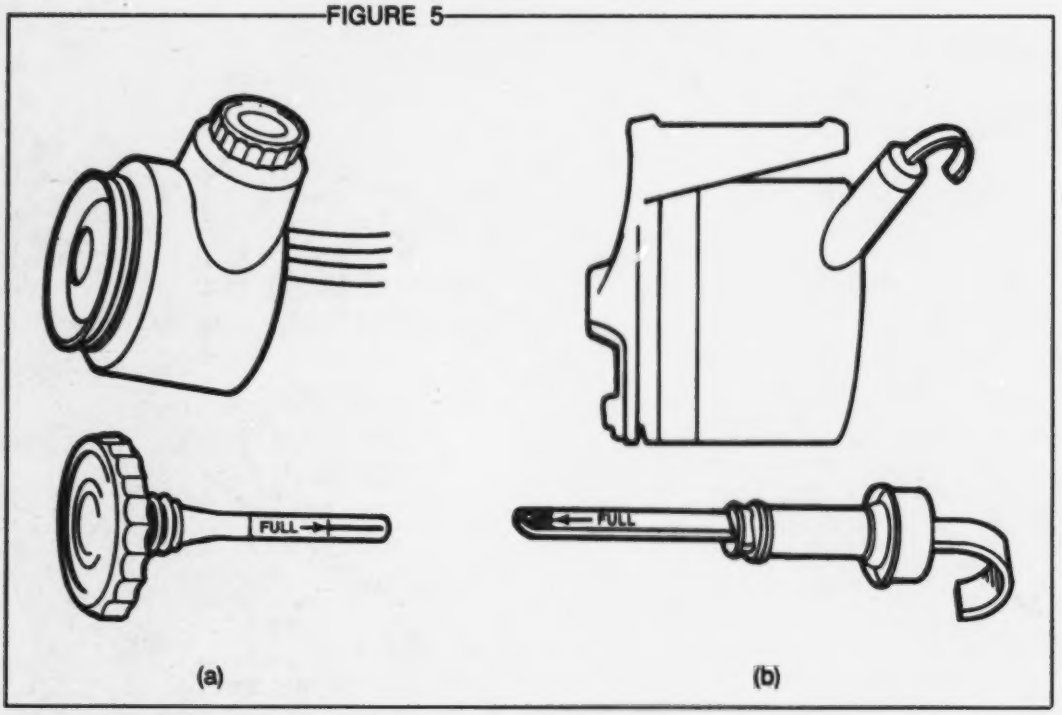
1. Shut engine off

   NOTE: When you check the fluid level in the reservoir of a power-steering system, the engine should **not** be running, but it should still be warm to give an accurate reading on the dipstick.

2. Locate dipstick

NOTE: The dipstick on power-steering systems is often located on the filler cap (see Figure 5-a), but it may be located elsewhere on the reservoir (see Figure 5-b). Check vehicle service manual for dipstick location.

FIGURE 5



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3. Wipe housing around dipstick so that dirt does not fall into the reservoir
4. Remove dipstick from housing
5. Check fluid level: Fluid should be level with FULL mark on dipstick (See Figure 5)
6. Record fluid level in proper place on checksheet

PROCEDURE

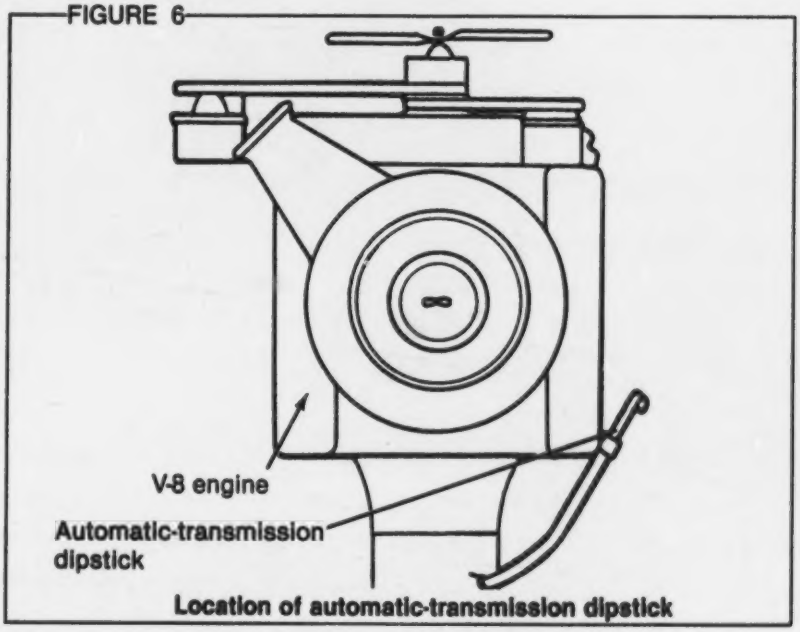
For checking automatic-transmission-fluid level

1. Check service manual to determine proper selector position for procedure and proper interpretation of marking system for vehicle's transmission dipstick
2. Drive vehicle onto level floor
3. While holding your foot on the brake, move gearshift through the shift pattern, ending in proper selector position (usually PARK or NEUTRAL)

4. Set emergency brake and leave engine running at curb-idle speed for a minimum of 60 seconds

5. Locate transmission dipstick (Figure 6)

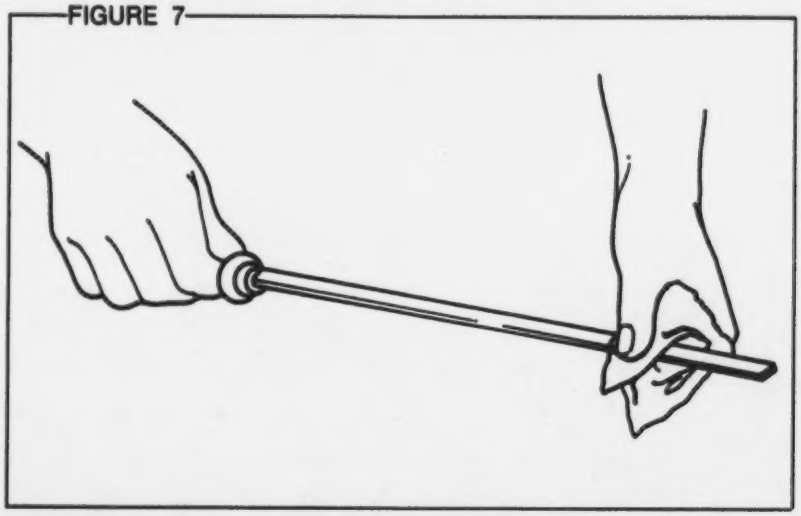
FIGURE 6



Location of automatic-transmission dipstick

6. Remove transmission dipstick and wipe it clean (Figure 7)

FIGURE 7



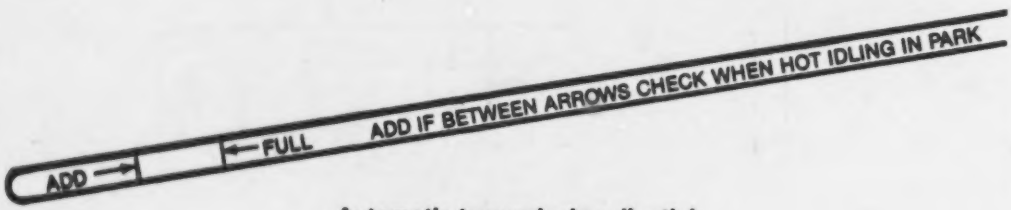
Figures 6 and 7 from *Introduction to Automotive Mechanics, Unit 2: Lubrication, Cooling, and Safety Inspection Services*, copyright ©1982, by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

7. Reinsert dipstick into transmission until dipstick is securely seated

8. Withdraw dipstick and check fluid level

   NOTE: Dipsticks usually have two marks: FULL and ADD. (See Figure 8.) Fluid is usually added only when the level is at or below the ADD mark (the ADD mark on most automatic transmission dipsticks generally indicates 1 pint low), but consult the service manual for proper interpretation of the marking system for the vehicle's transmission dipstick.

FIGURE 8



Automatic-transmission dipstick

9. Record transmission-fluid level in proper place on checksheet

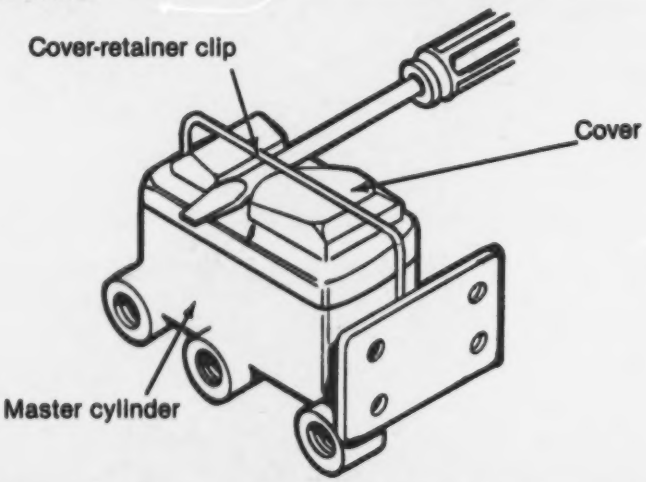
PROCEDURE

For checking brake-fluid level in diaphragm-reservoir master cylinder

1. Wipe dirt and grease from master-cylinder cover (See Figure 9)

2. Insert screwdriver blade under one side of master-cylinder cover-retainer clip; pry retainer clip from cover (Figure 9)

FIGURE 9



Figures 8 and 9, from *Introduction to Automotive Mechanics, Unit 2: Lubrication, Cooling, and Safety Inspection Services*, copyright ©1982, by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

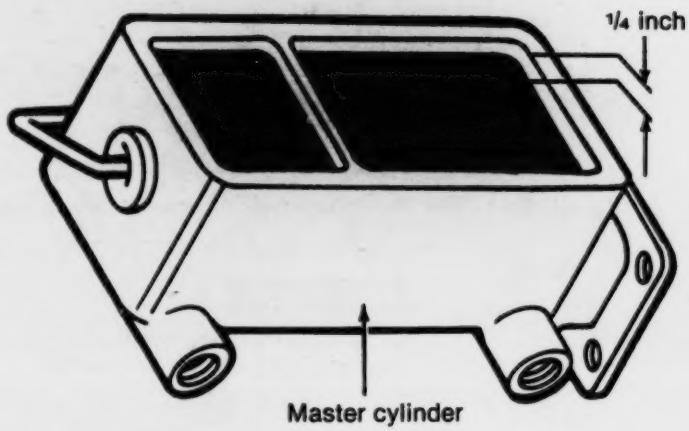
3. Remove cover from master cylinder

4. Check brake-fluid level: Diaphragm-reservoir master cylinder should be filled to within 1/4 inch of the top of the reservoir (Figure 10)

► WARNING ◄

Do **not** drip brake fluid on vehicle's painted or chromed surfaces. Do **not** allow brake fluid to contact skin.

FIGURE 10



Proper brake-fluid level

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5. Record brake-fluid level in proper place on checksheet

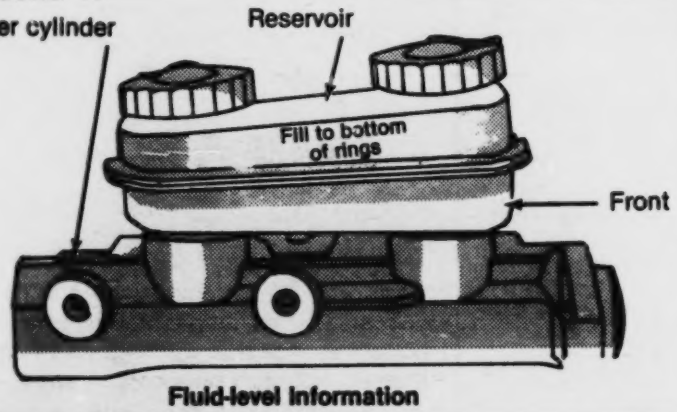
PROCEDURE

For checking brake-fluid level in composite-reservoir master cylinder

1. Wipe dirt and grease from reservoir (See Figure 11)

2. Check brake-fluid level: Composite reservoirs are marked with phrases such as FILL TO or FILL TO BOTTOM OF RINGS to indicate proper fluid level (See Figure 11)

FIGURE 11



Fluid-level information

Used with permission of Chrysler Corporation.

3. Record brake-fluid level in proper place on checksheet

PROCEDURE

For checking windshield-washer-fluid level

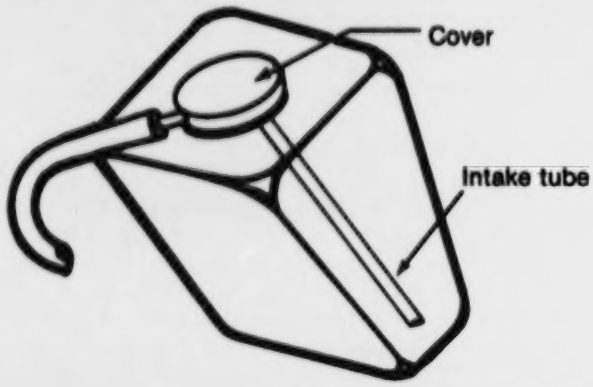
1. Locate windshield-washer-fluid reservoir

   CAUTION

   Be certain you have located the windshield-washer-fluid reservoir and not the coolant recovery reservoir.

2. Check level of fluid in reservoir: Fluid level is low if it is nearing the bottom of the intake tube inside the reservoir (Figure 12)

FIGURE 12



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3. Record fluid level in proper place on checksheet
4. Clean work area and properly store equipment and materials

JOB SHEET 3

STUDY AUTOMOTIVE DESIGN

OBJECTIVE 11

Clean and service batteries

INTRODUCTION

Your customer usually forgets all about the storage battery in his or her vehicle until he or she experiences this typical battery problem: one cold morning the engine will not crank over fast enough to start, or it will not crank over at all. As a service specialist, you can gain a satisfied, long-term customer by providing the periodic battery service that will help your customer avoid having a vehicle that will not start on a cold morning.

There are usually only seven steps to periodic battery service (sometimes an additional step must be added if the battery has to be removed and then replaced during service):

1. Visually inspecting the battery.
2. Disconnecting battery cables.
3. Cleaning corrosion from battery terminals and cable clamps.
4. Cleaning loose dirt and corrosion from the battery case.
5. Reconnecting battery cables.
6. Spreading anticorrosion compound on terminals and cable clamps.
7. Checking battery electrolyte level (if possible).

However, battery service can be tricky. There are serviceable (nonsealed) batteries and nonserviceable (sealed) batteries, and there are batteries with top-mounted terminals and side-mounted terminals. Service specialists must be able to look at a battery and recognize problems that may be encountered from either top- or side-mounted terminals, or from sealed and nonsealed batteries. Specialists must know that they can service a nonsealed battery by removing the vent caps, looking down into the battery cells, and adding water if needed. And, they must also know that a sealed battery cannot be serviced in the same way. A sealed battery never requires the addition of water as nonsealed batteries do, but specialists can make sure the battery connections are tight at the terminals. Procedures for various types of batteries are described below.

Battery service can also be dangerous. The following lists some of the safety precautions specialists should observe during battery service.

- Gases that form in the tops of battery cells during charging are very explosive. Never bring an open flame near a recently charged battery, and never smoke near one.

- Batteries contain an agent called *electrolyte*. Sulfuric acid is the active ingredient in electrolyte. If sulfuric acid gets on the skin, it can cause serious burns. If it gets in the eyes, it can cause blindness. Safe service specialists always wear a full face shield to protect facial skin and eyes and rubber gloves and a rubber apron to protect clothing and skin on other parts of the body. And, they keep a container of baking soda nearby. Baking soda neutralizes any electrolyte that may contact the skin.

  Good service specialists also know first-aid procedures in case the worst should happen during battery service.

  —For electrolyte on the skin, remove clothing from affected area, if necessary, and immediately flush the skin with cool running water for at least 5 minutes; and then, pour a solution of baking soda and water (2 tablespoons of baking soda to 2 cups of water) over the skin until the electrolyte has been neutralized. Seek medical attention if blistering, burning, or peeling occurs.

  —For electrolyte in the eyes, immediately flush the eyes with cool running water for at least 15 minutes and notify a doctor at once. If medical help is not immediately available, neutralize acid with baking-soda-and-water solution, and then seek medical attention as quickly as possible.

EQUIPMENT AND MATERIALS

- Full face shield
- Rubber gloves
- Rubber apron
- 7/16- or 9/16-inch box-end wrench or special battery pliers
- Locking pliers or channel-lock pliers
- Battery clamp puller
- Wire brush or special terminal-post cleaning tool
- Bristle brush
- Baking-soda-and-water solution (2 tablespoons of baking soda to 2 cups of water)
- Anticorrosion compound (paste or spray)
- Shop towels
- Distilled water

PROCEDURE

For visually inspecting battery

1. Put on safety equipment: face shield, rubber gloves, and rubber apron; keep containers of baking soda and clean water nearby

2. Examine battery for signs of leakage, cracked case, missing vent plugs, and loose or missing cable clamps; notify instructor *if* any of these conditions exist

   NOTE: Leakage signs include corrosion on the battery carrier, inner fender, or car frame.

3. Check battery terminals and cable clamps for corrosion

NOTE: Battery terminals—especially top-mounted terminal posts—tend to build corrosion. Corrosion also builds up around the cable clamps and between the terminals and cable clamps.

PROCEDURE

For disconnecting battery cable clamps

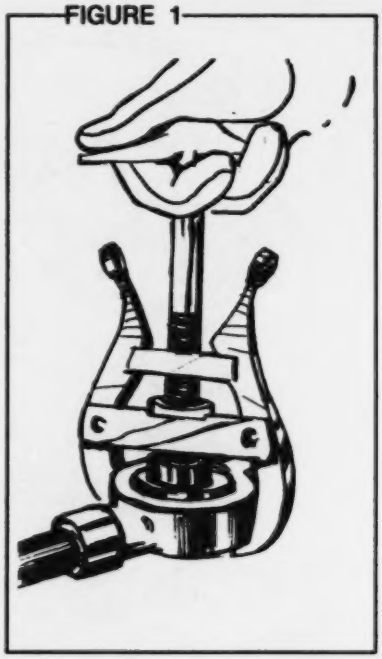
1. Disconnect negative-terminal (grounded-terminal) cable clamp

► WARNING ◄

Always remove negative-terminal clamp first. Removing the negative-terminal cable clamp first prevents accidental grounding of the positive-terminal cable clamp when it is disconnected.

a. On nut-and-bolt-type clamps, use a box wrench or special battery pliers to loosen clamp nut about 3/8 inch; *if* the clamp is heavily corroded, use a clamp puller to remove clamp from terminal (Figure 1)

FIGURE 1



b. On spring-ring-type clamps, squeeze the ends of the rings apart with locking or channel-lock pliers

2. Disconnect positive-terminal cable clamp, following the procedures in step 1

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PROCEDURE

For cleaning corrosion from battery terminals and cable clamps

CAUTION

Before proceeding with the following, check serviceable batteries to make sure that vent caps are tight and vent holes are open.

1. **Cleaning top-mounted terminals with posts and cables clamps**

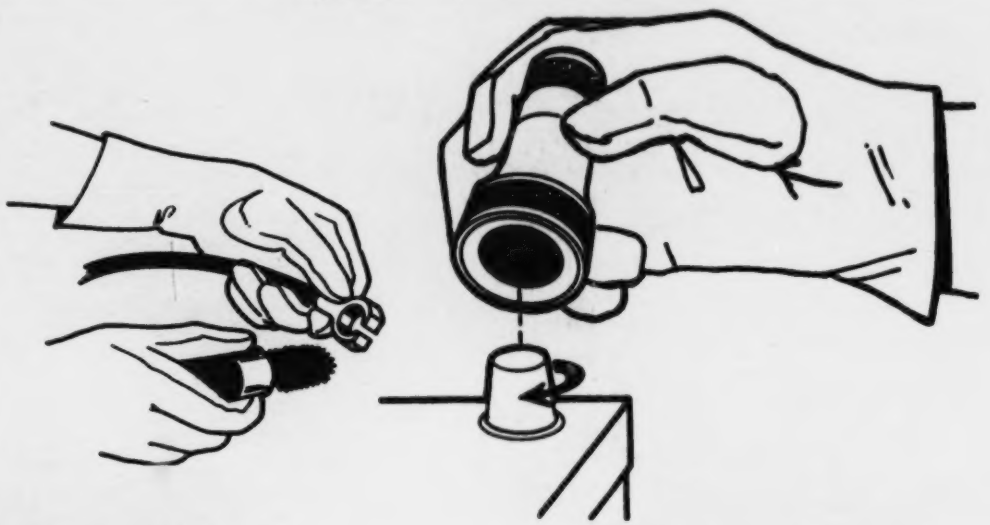
   a. **Using wire brush, clean cable clamps until metal looks shiny and bright (see Figure 2-a)**

   b. **Using terminal-post cleaning tool or a wire brush, clean terminal posts until the metal looks shiny and bright (Figure 2-b)**

CAUTION

Do not allow particles of corrosion to fall on vehicle parts while you are cleaning clamps and posts. Corrosion can ruin the vehicle's paint and corrode other vehicle parts.

FIGURE 2



(a) Cleaning cable clamps with wire brush

(b) Cleaning terminal post with battery terminal cleaner

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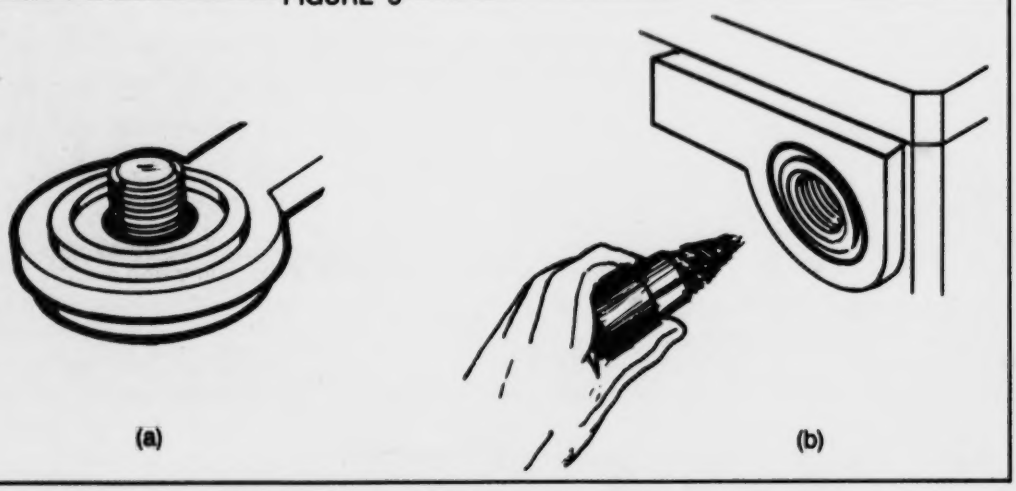
2. **Cleaning side-mounted terminals and terminal clamps**

   a. **Use wire brush to clean both sides of terminal clamp (see Figure 3-a)**

b. Use wire brush to clean terminal contact area (Figure 3-b)

FIGURE 3



PROCEDURE

For cleaning loose dirt and corrosion from battery case

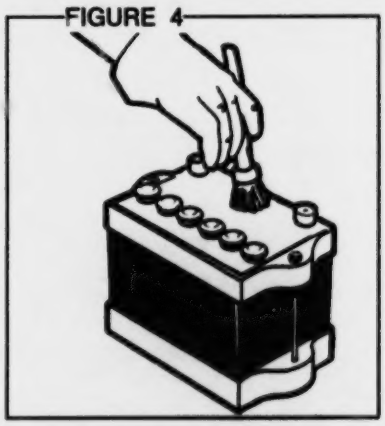
NOTE: Sometimes the battery is so corroded that it must be removed from the vehicle in order to be cleaned properly. *If* this is necessary, loosen battery hold-downs and remove battery from vehicle before proceeding with the following.

1. Using bristle brush, apply baking-soda-and-water solution to battery case, terminals, and cable clamp (Figure 4)

CAUTION

Do **not** allow baking-soda-and-water solution to get into vent holes.

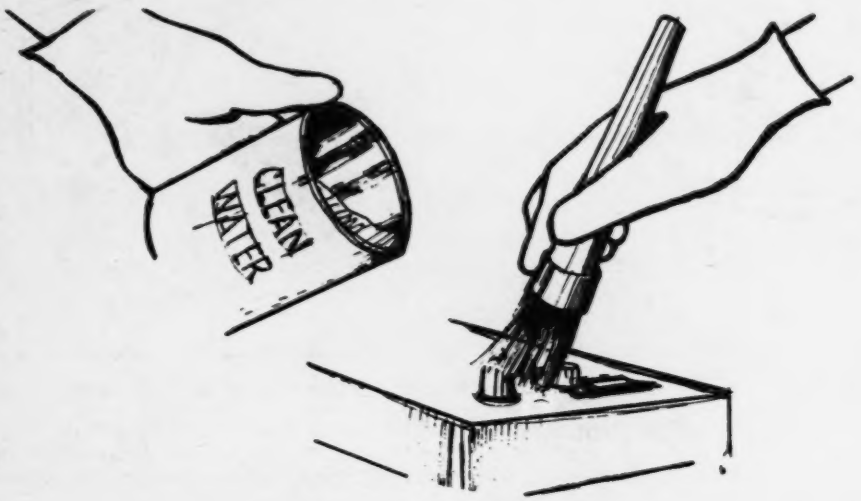
FIGURE 4



Figures 3 and 4 from *Introduction to Automotive Mechanics, Unit 2: Lubrication, Cooling, and Safety Inspection Services*, copyright © 1982, by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

2. When baking-soda solution stops foaming, wash residue away with clean water; brush with bristle brush to remove stubborn residue (Figure 5)

FIGURE 5



3. Dry battery, terminals, and cables with clean shop towel

► WARNING ◄

Never use an air hose to dry battery. The air can pull the electrolyte out through the vent caps and you can be sprayed with the acid mixture.

PROCEDURE

For reconnecting battery cables to terminals and applying an anticorrosive compound

NOTE: *If* battery had been removed from vehicle for cleaning, reinstall battery at this point and tighten hold-downs, being careful not to overtighten.

1. Reconnect positive cable to terminal, making sure cable clamp is tight and in correct position (See Figure 6)

► WARNING ◄

Always reconnect positive-terminal cable first and negative cable last.

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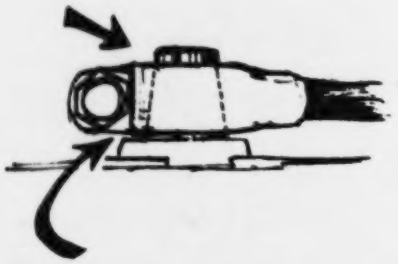
FIGURE 6



Correct position for post-type terminal: battery post is slightly above clamp.

2. Reconnect negative-terminal cable, making sure cable clamp is tight and in correct position
3. Spread or spray anticorrosion compound over cable clamps and terminals (Figure 7)

FIGURE 7

Spreading paste over cable clamp and terminal

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PROCEDURE

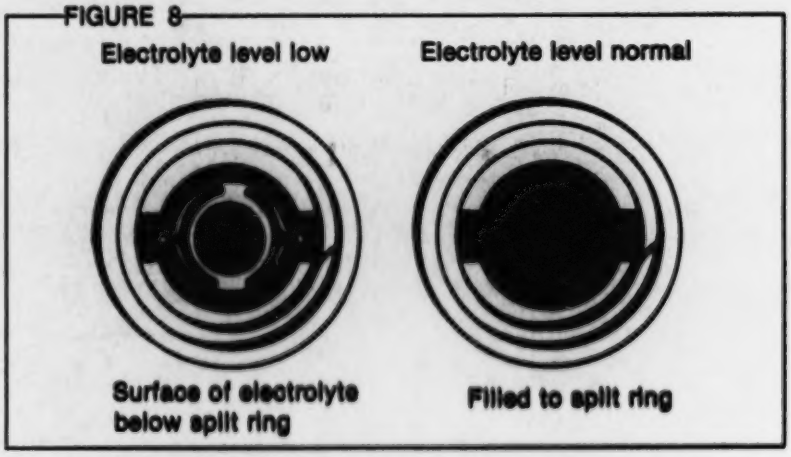
For inspecting electrolyte level of serviceable battery

NOTE: Nonserviceable batteries have a special indicator plug with a transparent rod extending down into the cell. The color of the indicator shows the condition of the battery. *If* the indicator shows green, the battery is charged. *If* the indicator is black, the battery is low and should be charged. *If* the indicator is light yellow, the battery is dead and should be discarded. On this type of battery the vent caps are not removed to check electrolyte level.

1. Remove each vent cap
2. Check electrolyte level

   NOTE: Most battery fill holes have tubes that extend down to the required electrolyte level. Some, however, have split rings in the cell covers that indicate proper electrolyte level (see Figure 8).

FIGURE 8



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3. *If* electrolyte level is low, slowly add distilled water to obtain proper level

   NOTE: Add water; do not add electrolyte. Also add water slowly; adding too much water will cause the electrolyte to overflow and corrode the battery case.

4. Replace vent caps
5. Check to be sure vent holes in vent caps are open

   ► WARNING ◄

   If vent holes are closed, gases can build up inside battery and cause the battery to expode.

6. Clean work area, remove safety equipment, and properly store equipment

JOB SHEET 4	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 12

Inspect drive belts

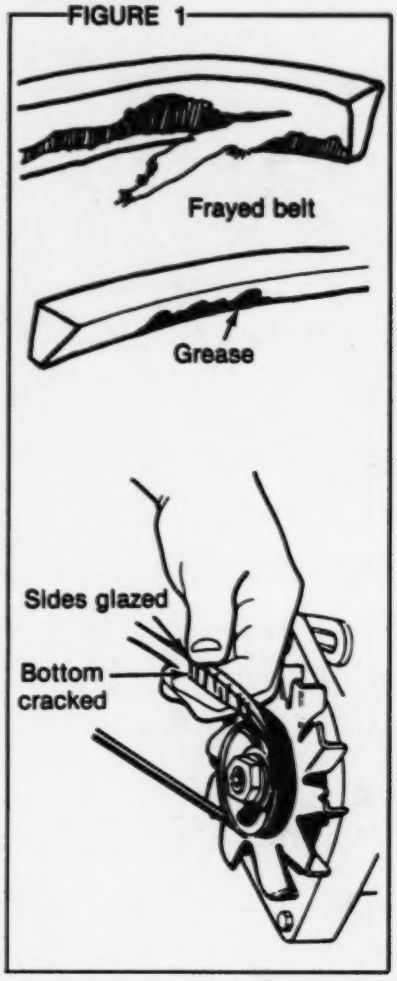
INTRODUCTION

Drive belts should be checked often. The proper maintenance of drive belts can lengthen the life of the belts and of the parts they drive. Belts drive a number of assemblies or components including the fan, water pump, alternator, power-steering pump, air-conditioner condenser, and air pump.

Some facts about drive-belt defects (see Figure 1):

- Small cracks can be found by flexing the belt and twisting it at the same time.
- Grease makes the belts slick and causes slippage.
- Glazing causes belt slippage.
- Belts may appear sound from the top, but they may have splits on the sides and bottom.
- Belts should ride on the sides of their pulleys. They should not touch the bottom of the pulley groove. Bottoming wear indicates either that the wrong belt was installed or that the belt is worn out. In either case, the belt should be replaced with a new one.
- The best way to check for looseness is to use a belt-tension gauge.

FIGURE 1



EQUIPMENT

- Belt-tension gauge

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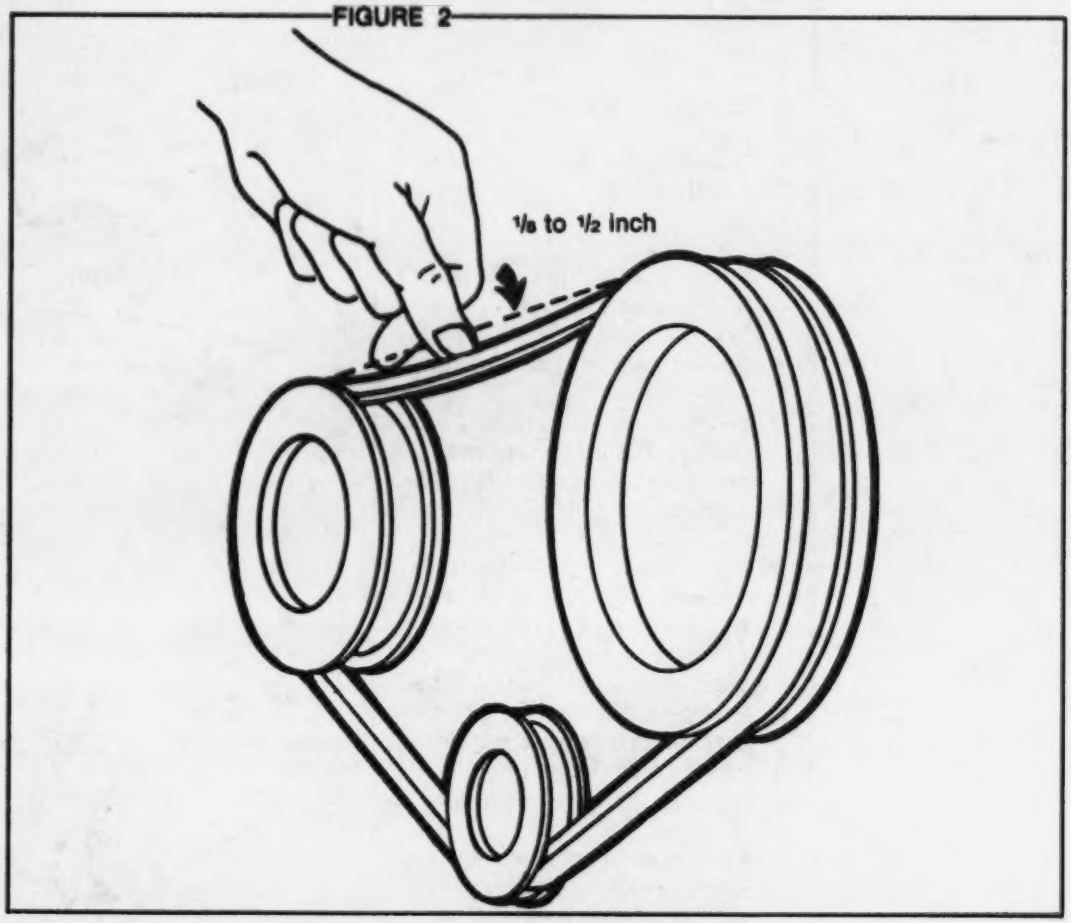
PROCEDURE

1. Inspect belt for cracks, grease, glazing, splits, and bottoming wear
2. Discard belt that has become too worn or frayed or has separated plies

   NOTE: Belt replacement will be covered later.
3. Manually inspect belt for proper tension or use belt-tension gauge: a belt should have ⅛- to ½-inch deflection (Figure 2)

   NOTE: Tightening of belts will be covered later.

FIGURE 2



4. Report any defects to your instructor
5. Clean work area and properly store equipment

Procedure Sheet 4 adapted from *Introduction to Automotive Mechanics, Unit 2: Lubrication, Cooling, and Safety Inspection Services*, copyright © 1982, by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

JOB SHEET 5	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 13

Check tire air pressure

INTRODUCTION

As simple as the procedure may seem, checking a vehicle's tires to make sure they are all at the correct air pressure is a very important service procedure. Maintaining tires at the correct pressure creates the proper tire **footprint** (the proper amount of tread contacts the road), which ensures long tire life and better vehicle traction, braking, and handling.

Maintaining tires with too little air pressure (underinflation) causes rapid tire wear at the shoulder of the tread, difficult steering, pulling to one side, and front-wheel shimmy.

Maintaining tires with too much air pressure (overinflation) causes rapid center tire wear, a rough ride, loss of traction, and susceptibility to tire damage from cuts and punctures.

Maintaining uneven pressures among the vehicle's tires causes the vehicle to wander when being driven down the highway or to pull one way or the other when the brakes are applied.

- To determine proper air pressure for each tire, check the placards vehicle manufacturers attach to the chassis. Check service manuals for the location of the placard on the particular vehicle you are working with. For example, in Chrysler's 1986 front-wheel-drive vehicles, the placards are attached to the left-front door-latch pillar.

  The air pressures printed on these placards have been carefully selected by the vehicle manufacturers to provide the safest and most comfortable ride.

- Inflation pressures given on the placards are **cold inflation pressures**. This means that the air pressure must be checked only when the tire is cold (when the vehicle has not been driven for at least 3 hours or has been driven less than 1 mile after being inoperative for at least 3 hours).

  If the tires are checked when they are **hot** (when the vehicle has been driven 2 or more miles), pressures can be increased from 2 to 6 pounds per square inch. This is a normal pressure increase that occurs as heat builds up during driving. Do not reduce this normal buildup; the air pressure will drop when the tire cools.

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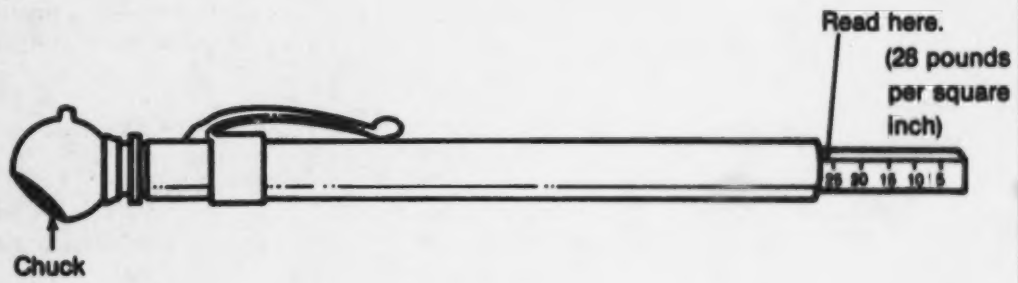
- Check the sidewall of each tire for the tire manufacturer's recommended air pressure. Compare the vehicle manufacturer's recommendation to the tire manufacturer's recommendation. The tire manufacturer's recommended air pressure is usually the maximum air pressure the tire has been designed to withstand. Pressures should never exceed those printed on the tire.
- Always check air pressure with a high-quality gauge. Accuracy is important. However, the type of gauge used is not important. You may use either the type attached to an air hose or the type that is a tool separate from the hose. See Figure 1 below.

FIGURE 1



Air-pressure gauge

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EQUIPMENT AND MATERIALS

- Tire air-pressure gauge
- Air hose
- Compressor or air tank
- Service manual

PROCEDURE

1. Consult service manual to determine correct pressure for tire
2. Remove valve-stem cap from tire
3. Press pressure-gauge chuck (see Figure 1) onto tire's valve stem
4. Read air-pressure gauge (see Figure 1)
5. Compare gauge reading with correct pressure for tire

6. *If* air pressure should be increased, use the following procedures

   a. Press air-hose chuck onto the valve stem to add air

   b. Stop frequently and check air pressure until desired pressure is obtained

      CAUTION

      Do **not** exceed the tire manufacturer's recommendation.

   c. Replace valve-stem cap and tighten fingertight

7. *If* air pressure should be decreased, use the following procedures

   a. Press pressure-gauge chuck over valve stem

   b. Press in on valve core until you hear air escaping

   c. Stop frequently and check air pressure until desired pressure is reached

   d. Replace valve-stem cap and tighten fingertight

8. Repeat steps 1 through 7 for remaining tires

9. Clean work area and properly store equipment

JOB SHEET 6	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 14

Perform vehicle safety inspection

INTRODUCTION

A safety device is a device designed to help the driver avoid accidents and prevent damage and injury. Vehicle systems have always been designed to include some safety devices. Brakes, lights, and switches were among the first safety devices used. Government regulations and public demand have increased the number of safety devices used in today's vehicles.

Government regulations and public demand have also brought about the inspection of vehicles to determine that the safety devices required by law are present and operating properly in every vehicle traveling on public roads. Automotive service specialists are usually charged with conducting these very important safety inspections. When conducting this type of inspection, the service specialist **must** follow the mandated procedure to the letter. Failure to reject a vehicle that does not meet inspection requirements could result in loss—loss of the inspection-station license, loss of money through fines, and loss of life when an accident results.

The following procedures are based on the safety inspection required by the state of Oklahoma for passenger cars, station wagons, pickups, trucks, truck tractors, school buses converted for other purposes, and motor homes less then 80 inches in overall width. You are to read each of the guidelines below as well as Student Supplements 2 and 3 before performing these procedures. As a part of each procedure, you are to fill out the checksheet in Student Supplement 4.

Guidelines for conducting safety inspection of the brake system

The safety inspections of the brake-system-failure indicator lamp and brake performance are **not** to be conducted in the inspection lane. These procedures are to be performed when the vehicle is outside in a space where it can be driven back and forth in relative safety should the brakes not be operating properly. When the vehicle has been determined to be safe enough, proceed with the inspection.

A brake inspection also requires that you be able to apply a 25-pound force to the brake pedal. As a general rule, 25 pounds of force is the normal amount of pressure you apply to the brake pedal to hold a vehicle at a stop light. However, to make certain you are applying the proper amount of pressure, practice by applying pressure to a scale until you are able to consistently apply 25 pounds of force to the scale.

Guidelines for conducting safety inspection of the exhaust system

The inspection of the exhaust system must be conducted when you are under the vehicle and the vehicle's motor is running. Follow all safety precautions for properly elevating a vehicle and for preventing carbon-monoxide poisoning. Also remember not to touch the hot components of the exhaust system.

Guidelines for conducting safety inspection of the steering system

In order to conduct this procedure, you will need to understand the meanings of the terms *jamming* and *lash*.

- Jamming of the steering system occurs when there is any obstruction to the turning of the steering wheel caused by interference with any component of the steering system. Interference with steering-system components may include a damaged fender or tires that are too large.
- Lash is the distance in which the steering wheel can be turned through some part of a revolution without front-wheel motion.

The vehicle must be placed on a dry, level surface to achieve accurate results when an inspection of the steering system is performed.

Guidelines for conducting safety inspection of the lighting equipment

Before you can conduct this procedure, you must be familiar with the number, placement, and color of the lights and reflectors required on vehicles by the laws of your state. Oklahoma requirements are given in Student Supplement 2. Study this supplement and keep it available during the inspection procedure.

Guidelines for conducting safety inspection of the windshield and other glazing material

Before you can conduct a safety inspection of a vehicle's glazing material, you must know the standard glazing-material codes and understand certain terms that describe glazing-material defects. Codes and terms associated with glazing-material inspection are given in Student Supplement 3. Study this supplement and keep it available during the inspection procedure.

EQUIPMENT AND MATERIALS

- 1- and 2-inch blocks (or ruler) for measuring brake-pedal clearance
- Ruler
- Lift, jack, or inspection pit
- Tread-depth gauge calibrated in thirty-seconds of an inch
- Service manual for make and model of vehicle
- Student Supplement 2
- Student Supplement 3
- Student Supplement 4

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PROCEDURE

For conducting safety inspection of the brake system

1. Check failure-indicator-lamp function

   ► WARNING ◄

   Perform this procedure before entering the inspection lane.

   NOTE: The brake-system-failure indicator lamp is required by the Federal Motor Vehicle Safety Standards (FMVSS) set on every passenger car manufactured on or after January 1, 1968, and on other types of motor vehicles manufactured on or after September 1, 1975.

   a. Apply parking brake and turn ignition to START, or verify lamp operation by means indicated by vehicle manufacturer

   b. Record vehicle rating

      NOTE: Do **not** reject a vehicle if the lamp is not operating. Only advise owner of the defect.

2. Check service-brake performance

   ► WARNING ◄

   Perform this part of the procedure before entering the inspection lane.

   a. Drive vehicle back and forth, applying brakes occasionally to see whether brakes stop the vehicle properly and to listen for any obvious metal-to-metal contact when brakes are applied

   b. Reject vehicle *if*

      (1) Brakes do **not** stop vehicle

      (2) There is an obvious metal-to-metal-contact sound when brakes are applied

3. Check brake-system integrity

   NOTE: You may now enter the inspection lane.

   a. Place your foot on the brake pedal with a force of 25 pounds, and check to see that the pedal height can be maintained for 15 seconds

      NOTE: *If* the brake-pedal height cannot be maintained for 15 seconds, there may be leakage visible at the wheel or the master cylinder.

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b. Check for illumination of the failure-indicator lamp

c. Reject vehicle *if*

(1) Brake-pedal height cannot be maintained for 15 seconds

(2) Failure-indicator lamp illuminates

d. Record vehicle rating

4. Check brake-pedal reserve

NOTE: The engine must be running when you check power-assisted brakes.

a. Depress brake pedal once with 25 pounds of force

b. Measure distance from bottom of brake pedal to floor

NOTE: Use a 1-inch block or a ruler to check vehicles with power-assisted brakes. Use a 2-inch block or a ruler to check vehicles with hydraulic or mechanical brakes.

c. Reject vehicle *if*, upon first application

(1) Brake pedal on power-assisted systems does not have at least a 1-inch clearance from the bottom of the brake pedal to the floor

(2) Brake pedal on hydraulic or mechanical systems does not have at least a 2-inch clearance from the bottom of the pedal to the floor

d. Record vehicle rating

5. Check brake power-unit function (*if* vehicle is so equipped)

NOTE: The engine must be turned off before this procedure is performed.

a. Apply service brake several times to destroy vacuum in system

b. Depress service-brake pedal once with 25 pounds of force

c. While maintaining force on service-brake pedal, start engine and note brake-pedal movement

NOTE: The brake pedal should fall slightly under force when the engine is started.

d. Reject vehicle *if* service-brake pedal does **not** fall slightly when engine is started

e. Record vehicle rating

6. Visually inspect brake system

a. Inspect master cylinder for leakage

NOTE: To conduct this part of the procedure, you must raise the vehicle's hood, remove the floor boards, or whatever is necessary to expose the master cylinder for inspection.

b. Check brakes, brake lines, hoses, and wheel cylinders

NOTE: To conduct this part of the procedure, the vehicle must be placed on a lift or jack and raised to maximum height, *or* vehicle must be driven over an inspection pit.

(1) Check to see that vehicle is equipped with all brakes required by law

(2) Inspect brakes to see that all required brakes are connected and operable

(3) Inspect brake lines, hoses, and wheel cylinders for leakage

c. Check parking-brake function

NOTE: Vehicles manufactured in 1969 or before are exempt from parking-brake inspection. Vehicles made in 1970 and later are inspected for proper parking-brake function.

(1) Set parking brake

(2) *If* vehicle has an automatic transmission, position shift lever in DRIVE and then slightly accelerate engine

NOTE: The parking brake should hold the vehicle in place; however, some vehicles have a parking-brake-release feature that is activated when the shift lever is moved from the PARK position. On these vehicles, foot pressure must be maintained on the parking-brake pedal during the test.

(3) *If* vehicle has a manual transmission, position shift lever in LOW with the clutch engaged, slowly disengage clutch, and then slightly accelerate engine

NOTE: Parking brake should hold vehicle in place.

d. Reject vehicle *if*

(1) Vehicle is not equipped with all brakes required by law

(2) Any brake required by law has been disconnected or made inoperable

(3) Any leaks are detected in the master cylinder, brake lines, hoses, or wheel cylinders

(4) Parking brake fails to hold vehicle in place

e. Record vehicle rating

PROCEDURE

For conducting safety inspection of wheels and tires

1. Inspect wheels

a. Inspect all wheels for cracks

b. Inspect all wheels to make certain they are securely fastened to hubs

c. Reject vehicle *if* any wheel is cracked or loose on the hub

d. Record vehicle rating

2. Inspect tires

a. Measure tread depth by taking three measurements at least 12 inches apart along the major groove at the center of each tire (see Figure 1)

NOTE: Tire tread depth should measure at least $^{2}/_{32}$ ($^{1}/_{16}$) inch except for truck-tractor front tires on the steering axles. The tread depth of these tires should measure at least $^{4}/_{32}$ ($^{1}/_{8}$) inch.

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FIGURE 1

b. Inspect all tires for cord exposure in the tread area

c. Inspect all tires to determine that no tire has been regrooved or recut below the original groove depth

NOTE: Tires especially designed with an under-rubber sufficient for regrooving and so marked by the manufacturer are an exception to the rule and their use will **not** affect the vehicle rating.

d. Inspect all tires to determine that no tire is marked with FARM IMPLEMENT ONLY, NOT FOR HIGHWAY USE, or any other mark that indicates tire is **not** for normal highway use; check to see that such markings have **not** been altered or removed

e. Inspect all tires for bulges, bumps, and knots in the tread or sidewall area—defects that can indicate internal ply separation

f. Reject vehicle *if*

(1) Any tire is worn to the point where less than $^{2}/_{32}$ inch of tread remains at two of the three measurements taken

(2) Any front tire on the steering axle of a truck tractor is worn to the point where less than 4/32 inch of tread remains at two of the three measurements taken

(3) Any tire has ply or cord exposed in the tread area

(4) Any tire has been regrooved or cut below the original groove depth—except tires that have been designed and are so marked for regrooving

(5) Any tire is marked with FARM EQUIPMENT ONLY, NOT FOR HIGHWAY USE, or any other mark indicating it is not designed for highway use, or if any such mark has been altered or removed

(6) Any tire has bulges, bumps, or knots showing in tread or sidewall

PROCEDURE

For conducting safety inspection of exhaust system

CAUTION

This procedure is conducted while you are under the vehicle and the vehicle's motor is running. Follow all safety precautions for properly elevating a vehicle and for preventing carbon-monoxide poisoning.

1. Visually inspect exhaust system

   CAUTION

   Do **not** touch hot exhaust-system components.

   a. Check to see whether vehicle is equipped with a muffler and a tail pipe

   b. Inspect muffler, tail pipe, and manifold exhaust piping

      (1) Inspect muffler for any welding repairs, jackets, or patches

      NOTE: Muffler repairs of any kind are **not** allowed.

      (2) Inspect any welding done on manifold exhaust piping or tail piping

      NOTE: Manifold exhaust piping and exhaust piping may be welded to the muffler with a permanent-type electric or acetylene weld. These types of welds will **not** affect the vehicle rating.

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(3) Inspect the following components for obvious leaks: exhaust manifold, piping leading from flange(s) of the exhaust manifold(s) to and include muffler(s), tail piping from muffler(s), all connections

NOTE: Some mufflers have been equipped by the manufacturer with drain holes. These holes will not affect the vehicle rating.

2. Reject vehicle *if*

   a. Vehicle has no muffler

   b. Vehicle has no tail pipe

   c. There are obvious leaks in the exhaust system

   d. Exhaust fumes are emitted other than to the side or to the rear of the extreme edge of the vehicle

   e. Muffler has been repaired with a jacket or patch, or tail piping has been repaired by any means other than a permanent-type electric or acetylene weld

3. Record vehicle rating

PROCEDURE

For conducting safety inspection of the steering system

1. Inspect steering system for possible jamming, roughness, or binding

   NOTE: The weight of the vehicle must be on the tires, the vehicle on a dry surface, and the wheels positioned straight ahead when you conduct this part of the procedure. Also, *if* the vehicle is equipped with power steering, the engine must be running.

   a. Turn the steering wheel to make the wheels turn from full right to full left

   b. Reject vehicle *if* jamming, roughness, or binding occurs when the wheels are turned from full right to full left

   c. Record vehicle rating

2. Inspect steering-wheel lash

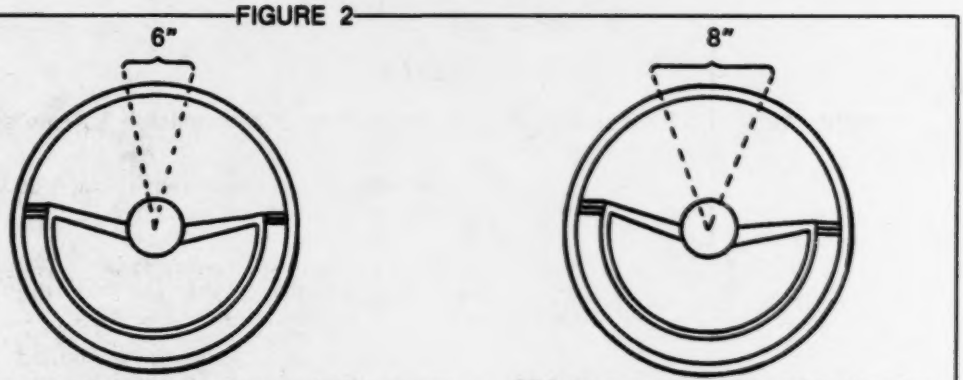
   NOTE: The weight of the vehicle must be on the tires, the vehicle on a dry surface, and the wheels positioned straight ahead when you conduct this procedure. And, *if* the vehicle is equipped with power steering, the engine must be running. You will also need an assistant to observe front-wheel movement.

a. Turn the steering wheel in both directions until turning motion can be observed at the front wheels

b. Measure steering-wheel lash

NOTE: No more than 6 inches of free movement is allowed in steering wheels measuring up to and including 18 inches in diameter, or more than 8 inches in steering wheels over 18 inches in diameter. See Figure 2.

FIGURE 2



6" free movement allowed in steering wheels up to and including 18" in diameter

8" free movement allowed in steering wheels over 18" in diameter

c. Inspect steering wheel to see that it is fastened securely

d. Reject vehicle *if*

(1) There is more than 6 inches of lash in a steering wheel measuring up to and including 18 inches in diameter

(2) There is more than 8 inches of lash in a steering wheel measuring over 18 inches in diameter

(3) Steering wheel is **not** securely fastened

e. Record vehicle rating

PROCEDURE

For conducting safety inspection of the suspension system

1. Visually inspect shock absorbers or struts

CAUTION

To conduct this part of the procedure, the vehicle must be placed on a lift or jack and raised to maximum height, or it must be driven over an inspection pit. Follow all safety precautions for properly elevating a vehicle.

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a. Check to make certain shock absorbers/struts are present

b. Inspect to make certain shock absorbers/struts have **not** been disconnected

c. Inspect to make certain shock absorbers/struts are **not** broken

2. Reject vehicle // any shock absorber/strut is missing, disconnected, or broken

3. Record vehicle rating

PROCEDURE

For conducting safety inspection of the vehicle's lighting equipment

1. Operate headlight switch and dimmer switch to make sure they function properly

2. Operate turn-signal lever for both left and right turn to make sure they function properly

   NOTE: Turn-signal lever should **not** require assistance to remain in the turn position.

3. Check to see that vehicle is properly equipped with all required lights and reflectors

   NOTE: See Student Supplement 2 for proper light placement and sizes for passenger vehicles, pickups, panel trucks, buses, and trucks less than 80 inches in overall width and for trucks or buses 80 inches or more in overall width.

4. Check all required lights to see that they function properly

   NOTE: Backup lights should remain lighted only when vehicle is in REVERSE gear.

5. Check all lights to see that they emit proper color

   NOTE: See Student Supplement 2.

6. Reject vehicle //

   a. Headlight switch does **not** operate properly

   b. Dimmer switch does **not** operate properly

   c. Turn-signal lever requires assistance to remain in turn position

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d. Vehicle is **not** equipped with all lights and reflectors required by law

e. Any lamp is **not** of an approved type or size

f. Any required lamp fails to function properly

g. Any light emits a color contrary to law

h. Backup lights remain lighted in any gear

PROCEDURE

For conducting safety inspection of the windshield and other glazing material

1. Check to see whether any nontransparent material (plywood, etc.) is being used to replace glazing material

   NOTE: A vehicle presented with glazing material removed—other than the windshield—may be approved as long as the removed glazing material does **not** leave exposed chips or edges that could injure a person.

2. Check to see that vehicle designed to carry passengers is equipped with a windshield

3. Check to see that all glazing material is marked with the manufacturer's trademark and the words AMERICAN STANDARD, or with the letters AS, followed by a reference number

4. Check reference number to determine that glazing material has been used in proper position

   NOTE: See Student Supplement 3 for definitions of *reference numbers*.

5. Inspect for outright breakage in windshield or in window on either side of driver

   NOTE: See Student Supplement 3 for definition of *outright breakage*.

6. Inspect for cracks in critical area; count and measure any cracks found in critical area

   NOTE: See Student Supplement 3 for definition of *critical area*. There can be no more than two cracks in the critical area and cracks can be no more than 12 inches long.

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7. Inspect for star breakage (shot damage) in critical area; measure diameter of any star breakage

   NOTE: See Student Supplement 3 for definition of *star breakage*. Star breakage in critical area can measure no more than 3 inches in diameter.

8. Reject vehicle *if*

   a. Vehicle does not have a windshield

   b. Windshield is not clearly marked or designated as AS-1 or AS-14 glass

      NOTE: Some vehicles manufactured or assembled prior to 1954 may be equipped with either AS-1 or AS-2 glass. *If* this is not clearly marked, the owner or operator must furnish a notarized statement from the glass company verifying that glass is AS-1 or AS-2 glass.

   c. Glazing material used in any other portions of vehicle (doors, windows, or rear window) is not approved glazing material

   d. There is any outright breakage in windshield or in window on either side of driver

   e. Critical area contains any star breakage 3 inches or more in diameter

   f. Critical area contains two or more cracks for any cracks 12 inches or more in length

9. Record vehicle rating

PROCEDURE

For conducting safety inspection of the windshield wipers

1. Check to determine that vehicle is equipped with original number of windshield wipers

   NOTE: The vehicle must have the same number of wipers as originally installed on the vehicle. *If* originally equipped with one wiper, only one is required. *If* originally equipped with more than one wiper, the same number of wipers must be present now. Replacement of vacuum with electric wipers or electric with vacuum wipers is permissible. Also, manually operated wipers are permissible *if* vehicle was originally equipped with such.

2. Check the location of the wiper controls

   NOTE: Controls must be within easy reach of the driver.

3. Check operation of the wiper controls

4. Turn wipers on and check wiper operation

   NOTE: Wiper operation must be adequate for cleaning rain, snow, or other moisture from the windshield.

5. Examine wiper blade(s); inspect rubber element(s) for tears; inspect metal parts for damage and proper construction

   NOTE: Rubber element(s) can have tears no longer than 1/4 inch; metal parts of wiper blade(s) **cannot** contact windshield.

6. Reject vehicle *if*

   a. Vehicle is **not** equipped with the number of wipers as originally equipped

   b. Wiper controls are **not** operating properly, or are located beyond the driver's reach

   c. Any wiper does **not** operate properly, or is improperly adjusted

   d. Any wiper is incapable of adequately cleaning the windshield

   e. Any part of the rubber element(s) is torn more than 1/4 inch

   f. Any part of the wiper blade(s) or arm(s) is damaged or comes in contact with the windshield

7. Record vehicle rating

PROCEDURE

For conducting safety inspection of the horn

1. Inspect to determine how horn is actuated

   NOTE: Horns may be actuated by buttons, rings, etc.

2. Check the location of the actuator

   NOTE: The actuator must be within easy reach of the driver.

3. Actuate the horn to determine level of sound emitted

   NOTE: The horn must emit a sound that would be audible under normal driving conditions.

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4. Reject vehicle *if*

   a. Actuator is **not** present or is **not** within easy reach of the driver

   b. Horn is **not** loud enough to be heard in normal traffic

5. Record vehicle rating

6. Remove vehicle from inspection lane; put away tools and equipment

Job Sheet 6 adapted with permission of the Motor Vehicle Inspection Division, Oklahoma Department of Public Safety, from *Oklahoma Official Motor Vehicle Emission and Mechanical Inspection Rules and Regulations Manual*, copyright © 1985. The job sheet is to be used as a general outline only. The information in the procedure is subject to change, and no authorization/license may be issued by completing this procedure.

PRACTICAL TEST	STUDY AUTOMOTIVE DESIGN

JOB SHEET 1

Clean an engine

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed air cleaner from engine.	_____	_____
3. Covered distributor and carburetor.	_____	_____
4. Applied solvent/degreaser properly and safely.	_____	_____
5. Used cleaner effectively and safely.	_____	_____
6. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

STUDY AUTOMOTIVE DESIGN

JOB SHEET 2

Perform vehicle fluid-level checks

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed correct procedure for checking vehicle's engine-oil level.	_____	_____
3. Followed correct procedure for checking vehicle's coolant level.	_____	_____
4. Followed correct procedure for checking vehicle's steering-fluid level.	_____	_____
5. Followed correct procedure for checking vehicle's transmission-fluid level.	_____	_____
6. Followed correct procedure for checking vehicle's brake-fluid level.	_____	_____
7. Followed correct procedure for checking vehicle's windshield-washer-fluid level.	_____	_____
8. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

STUDY AUTOMOTIVE DESIGN

JOB SHEET 3

Clean and service batteries

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Visually inspected battery.	____	____
3. Disconnected battery cables.	____	____
4. Cleaned loose dirt and corrosion from battery.	____	____
5. Reconnected battery cables properly.	____	____
6. Spread on anticorrosion compound.	____	____
7. Checked electrolyte level (if possible).	____	____
8. Cleaned work area and properly disposed of waste materials.	____	____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST	STUDY AUTOMOTIVE DESIGN

JOB SHEET 4

Inspect drive belts

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment.	_____	_____
2. Inspected belt for defects.	_____	_____
3. Inspected belt for proper tension.	_____	_____
4. Cleaned work area properly.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST	STUDY AUTOMOTIVE DESIGN

JOB SHEET 5

Check tire air pressure

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly inserted pressure gauge on valve stem.	_____	_____
3. Obtained proper gauge reading.	_____	_____
4. Compared gauge reading to proper reference materials.	_____	_____
5. Adjusted air pressure.	_____	_____
6. Cleaned work area properly.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

STUDY AUTOMOTIVE DESIGN

JOB SHEET 6

Perform vehicle safety inspection

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly inspected vehicle's brake system and determined correct rating.	_____	_____
3. Properly inspected vehicle's wheels and tires and determined correct rating.	_____	_____
4. Properly inspected vehicle's exhaust system and determined correct rating.	_____	_____
5. Properly inspected vehicle's steering system and determined correct rating.	_____	_____
6. Properly inspected vehicle's suspension system and determined correct rating.	_____	_____
7. Properly inspected vehicle's lighting system and determined correct rating.	_____	_____
8. Properly inspected vehicle's windshield and glazing material and determined correct rating.	_____	_____
9. Properly inspected vehicle's windshield wipers and determined correct rating.	_____	_____
10. Properly inspected vehicle's horn and determined correct rating.	_____	_____
11. Cleaned work area properly.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST

STUDY AUTOMOTIVE DESIGN

Name _____ Score _____

OBJECTIVE 1

Choose the definitions that best define the following terms associated with automotive design. Write the correct numbers in the blanks.

_____a. **Part**

1. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
2. Element of an assembly or component; member that is not normally useful by itself and cannot be disassembled further
3. Member of a component or system; two or more parts that function together in a component or system
4. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

_____b. **Automotive design**

1. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
2. A system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
3. Plan of the shape of and the materials to be used for elements of a vehicle and of the way these elements fit together and function to achieve certain purposes
4. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

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_____c. **Circuit**

1. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
2. Element of an assembly or component; member that is not normally useful by itself and cannot be disassembled further
3. Member of a component or system; two or more parts that function together in a component or system
4. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function

_____d. **Combustion**

1. Resistance to motion between two parts in contact
2. Undesirable element
3. Event or series of events that is repeated
4. Process of burning

_____e. **Install**

1. To secure a replacement part, assembly, or component in its proper location
2. To secure a previously removed or a replacement part, assembly, or component in its proper location; to add a completely new assembly or component
3. To secure a previously removed part, assembly, or component in its proper location
4. To take a part, assembly, or component from its location

_____f. **System**

1. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
2. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system
3. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
4. Member of a component or system; two or more parts that function together in a component or system

_____g. **Replace**

1. To secure a previously removed or a replacement part, assembly, or component in its proper location; to add a completely new assembly or component
2. To take apart an assembly, component, or system
3. To determine whether a substance or object meets specifications; to determine whether an event takes place
4. To secure a replacement part, assembly, or component in its proper location

_____h. **Assembly**

1. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
2. Member of a component or system; two or more parts that function together in a component or system
3. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function
4. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

_____i. **Remove**

1. To secure a replacement part, assembly, or component in its proper location
2. To determine whether a substance or object is present and meets specifications; to determine whether an event takes place
3. To take a part, assembly, or component from its location
4. To examine a part, assembly, or component for wear, damage, size, or shape

_____j. **Check**

1. To determine whether a substance or object is present and meets specifications; to determine whether an event takes place
2. To secure a previously removed or a replacement part, assembly, or component in its proper location; to add a completely new assembly or component
3. To examine a part, assembly, or component for wear, damage, size, or shape
4. To take a part, assembly, or component from its location

_____k. **Friction**

1. Undesirable element
2. Event or series of events that is repeated
3. Process of burning
4. Resistance to motion between two parts in contact

_____l. **Component**

1. Member of a component or system; two or more parts that function together in a component or system
2. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system
3. Member of a system defined by the flow of gas, liquid, or power from a given point to a second given point or from a given point through to its return to that point
4. Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function

_____m. **Reinstall**

1. To examine a part, assembly, or component for wear, damage, size, or shape
2. To take a part, assembly, or component from its location
3. To secure a replacement part, assembly, or component in its proper location
4. To secure a previously removed or a replacement part, assembly, or component in its proper location; to add a completely new assembly or component

_____n. **Disassemble**

1. To determine whether a substance or object is present and meets specifications; to determine whether an event takes place
2. To examine a part, assembly, or component for wear, damage, size, or shape
3. To take apart an assembly, component, or system
4. To take a part, assembly, or component from its location

_____o. **Contaminant**

1. Resistance to motion between two parts in contact
2. Undesirable element
3. Process of burning
4. Event or series of events that is repeated

_____p. **Inspect**

1. To determine whether a substance or object is present and meets specifications; to determine whether an event takes place
2. To take apart an assembly, component, or system
3. To take a part, assembly, or component from its location
4. To examine a part, assembly, or component for wear, damage, size, or shape

_____q. **Cycle**

1. Process of burning
2. Undesirable element
3. Resistance to motion between two parts in contact
4. Event or series of events that is repeated

OBJECTIVE 2

List the four major functional areas of a vehicle and write their purpose(s).

a. Functional area — _____

Purpose(s) — _____

_____

_____

_____

b. Functional area — _____

Purpose(s) — _____

_____

_____

_____

c. Functional area — _____

Purpose(s) — _____

_____

_____

_____

d. Functional area — _____

Purpose(s) — _____

_____

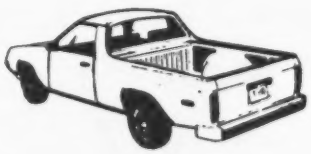
_____

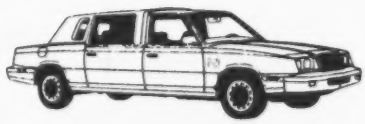
_____

OBJECTIVE 3

Identify the following illustrations of major vehicle body styles. Write the correct names in the blanks.

Two-door sedan
Three-door sedan
Four-door sedan
Five-door sedan
Hardtop
Convertible
Limousine
Station wagon
Pickup truck
Utility vehicle
Van





a. _____ b. _____

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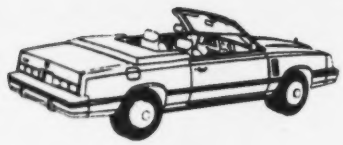
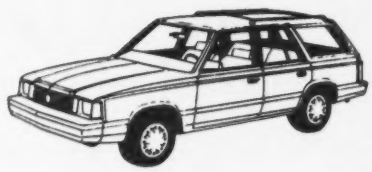
c. _____



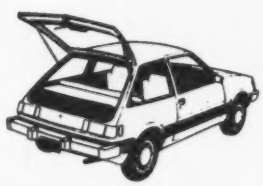
d. _____

e. _____

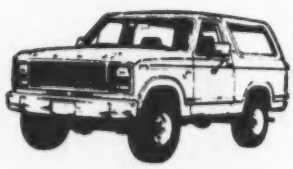


f. _____

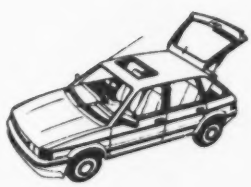
g. _____



h. _____



i. _____



j. _____

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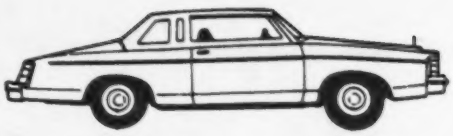

k. _____

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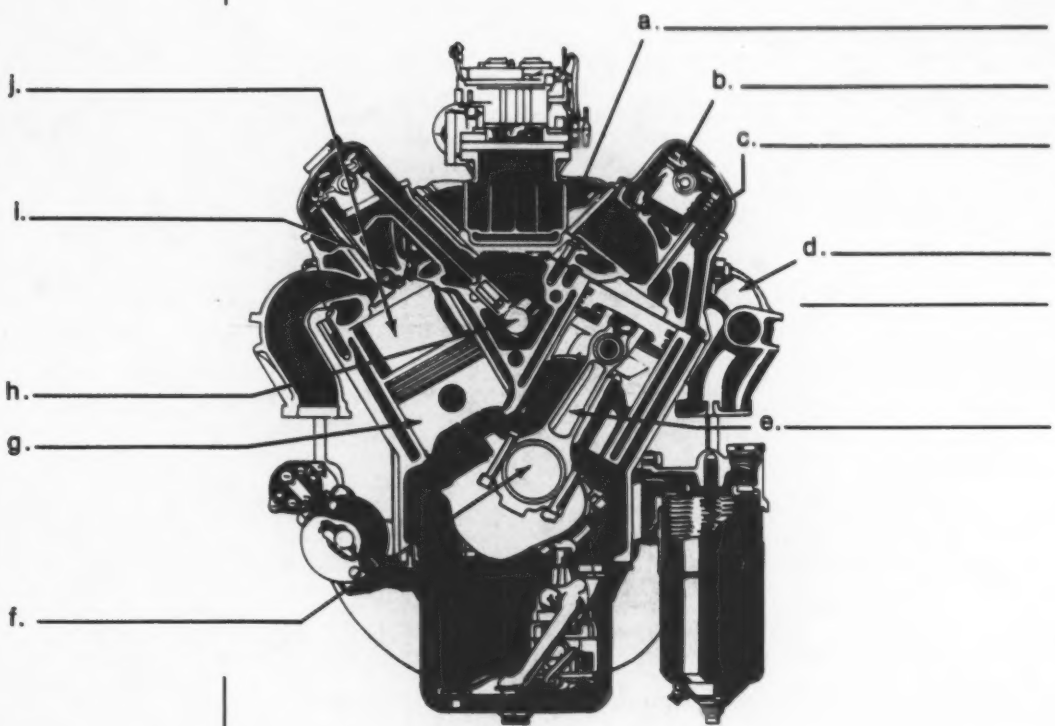
OBJECTIVE 4

Label basic components of the piston engine illustrated below. Write the correct names in the blanks.



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OBJECTIVE 5

Describe the sequence of actions that takes place during each of the strokes in the operation of a four-stroke-cycle piston engine.

a. **Intake stroke**

1. _____

_____

2. _____

_____

3. _____

_____

b. **Compression stroke** — _____

_____

_____

c. **Power stroke**

1. _____

_____

2. _____

_____

d. **Exhaust stroke**

1. _____

_____

2. _____

_____

OBJECTIVE 6

Use correct engine classification factors to describe two engines. Give a realistic example for each factor on the blanks provided. The examples for each factor should be different for the two engines.

	Engine 1	Engine 2
Cylinder number	_____	_____
Cylinder arrangement	_____	_____
Valve arrangement	_____	_____
Cooling-system type	_____	_____
Fuel type	_____	_____
Basic engine motion	_____	_____
Air/fuel-mixture control method	_____	_____

OBJECTIVE 8

Choose the correct purpose(s) of each of the major systems of a vehicle. Write the correct numbers in the blanks. Some blanks may contain more than one correct answer.

_____a. **Starting system**

1. Reduces noise caused by the combustion process within the engine
2. Promotes clean, efficient burning of fuel mixture within combustion chamber
3. Carries engine power to driving wheels
4. Controls and powers electric motor used to start engine easily

_____b. **Ignition system**

1. Controls and powers electric motor used to start engine easily
2. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
3. Delivers fuel to engine
4. Promotes clean, efficient burning of fuel mixture within combustion chamber

_____c. **Fuel system**

1. Delivers fuel to engine
2. Provides fuel storage
3. Mixes fuel with air in proper proportions for efficient burning in engine
4. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers

_____d. **Engine lubrication system**

1. Circulates air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
2. Reduces friction by providing lubrication around and between moving parts or contact points within engine
3. Helps transfer heat to cool engine
4. Cleans engine by removing contaminants

_____e. **Engine cooling system**

1. Circulates air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
2. Promotes clean, efficient burning of fuel mixture within combustion chamber
3. Minimizes escape of gasoline vapor from carburetor, fuel tank, fuel cap, and crankcase
4. Mixes fuel with air in proper proportions for efficient burning in engine

_____f. **Exhaust system**

1. Circulates air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
2. Reduces noise caused by the combustion process within the engine
3. Minimizes escape of gasoline vapors from carburetor, fuel tank, fuel cap, and crankcase
4. Directs harmful gases and heat away from engine

_____g. **Emission-control system**

1. Mixes fuel with air in proper proportions for efficient burning in engine
2. Minimizes escape of gasoline vapors from carburetor, fuel tank, fuel cap, and crankcase
3. Promotes clean, efficient burning of fuel mixture within combustion chamber
4. Helps exhaust gases continue burning process as they move through exhaust system

_____h. **Steering system**

1. Allows cornering without extreme body roll
2. Transmits road feel to driver's hands
3. Carries engine power to driving wheels
4. Allows driver to turn front wheels right or left to control vehicle direction

_____i. **Suspension system**

1. Allows driver to turn front wheels right or left to control vehicle direction
2. Allows cornering without extreme body roll
3. Absorbs road shock that results from wheels hitting holes or bumps
4. Transmits road feel to driver's hands

_____j. **Brake system**

1. Allows driver to reduce speed of or stop moving vehicle
2. Holds vehicle stationary when parked
3. Allows driver to turn front wheels right or left to control vehicle direction
4. Allows cornering without extreme body roll

_____k. **Charging system**

1. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
2. Powers electric motor used to start engine easily
3. Produces, controls, and monitors electrical current needed while vehicle is running
4. Cleans engine by removing contaminants

_____l. **Chassis electrical system**

1. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
2. Produces, controls, and monitors electrical current needed while vehicle is running
3. Powers electric motor used to start engine easily
4. Powers safety and warning devices, convenience accessories, and lights

_____m. **Heating and air-conditioning system**

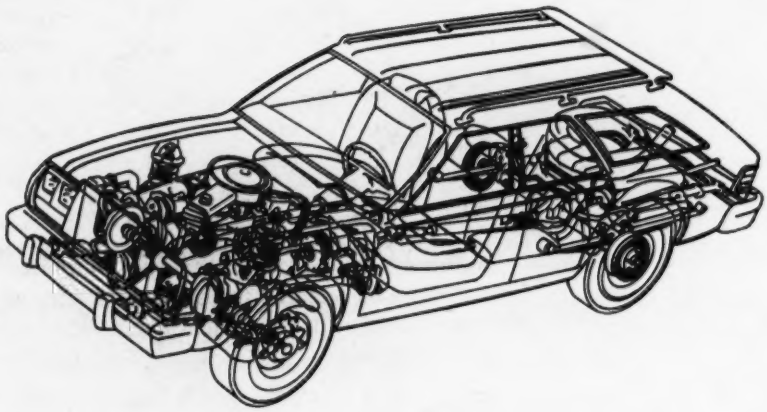
1. Pulls warm air from passenger compartment to be cooled, dehumidified, and cleaned, and then returns air back to passenger compartment
2. Helps transfer heat to cool engine
3. Circulates air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
4. Heats outside air and circulates heated air into passenger compartment

_____n. **Computer-control system**

1. Cleans engine by removing contaminants
2. Produces spark that ignites air/fuel mixture and begins combustion in engine combustion chambers
3. Produces, controls, and monitors electrical current needed while vehicle is running
4. Electronically monitors operation of various systems and adjusts those systems or provides driver or service person with information about those systems

OBJECTIVE 9

Classify the power-train design of the vehicles in the illustrations on the following page. Write the correct engine location and drivetrain design in the blanks provided.



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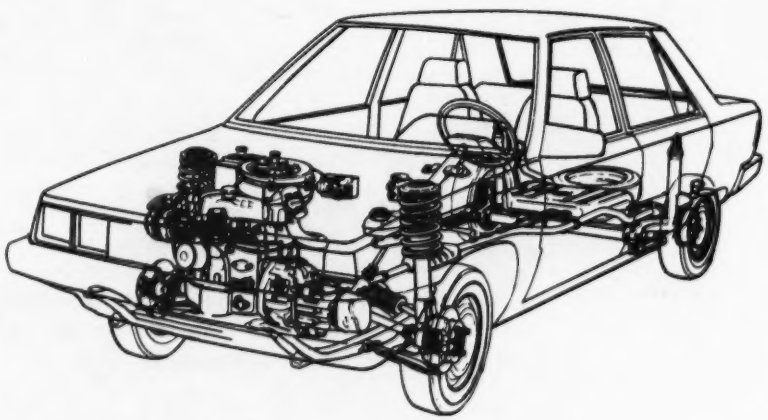
a. Engine location _____

Drivetrain design _____



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b. Engine location _____

Drivetrain design _____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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WRITTEN TEST ANSWERS	STUDY AUTOMOTIVE DESIGN

OBJECTIVE 1

a. 2
b. 3
c. 1
d. 4
e. 2
f. 3
g. 4
h. 2
i. 3
j. 1
k. 4
l. 2
m. 4
n. 3
o. 2
p. 4
q. 4

OBJECTIVE 2

a. Functional area—Body
Purpose(s) — Holds, carries, and protects passengers and cargo; encloses engine
b. Functional area — Chassis (frame)
Purpose(s) — Supports engine, wheels, and body
c. Functional area — Engine
Purpose(s) — Provides source of power to move vehicle
d. Functional area — Drivetrain
Purpose(s) — Carries engine power to driving wheels

OBJECTIVE 3

a. Pick-up truck
b. Limousine
c. Two-door sedan
d. Convertible
e. Four-door sedan
f. Station wagon
g. Van
h. Three-door sedan
i. Utility vehicle
j. Five-door sedan
k. Hardtop

OBJECTIVE 4

a. Camshaft
b. Rocker arm
c. Intake valve
d. Combustion chamber
e. Crankshaft
f. Connecting rod
g. Piston
h. Exhaust manifold
i. Exhaust valve
j. Intake manifold

OBJECTIVE 5

a. **Intake stroke**

1. Piston is located at topmost position in cylinder (top dead center [TDC]) with intake valve open and exhaust valve closed
2. Piston moves down cylinder, drawing air/fuel mixture into cylinder from carburetor
3. Piston reaches bottom of the cylinder (bottom dead center [BDC]) and intake valve closes

b. **Compression stroke** — Piston moves up cylinder, compressing air/fuel mixture and creating heat, which prepares fuel for instant ignition

c. **Power stroke**

1. Piston reaches top of cylinder and a spark from ignition system ignites air/fuel mixture
2. Burning gases expand rapidly and force piston down cylinder

c. **Exhaust stroke**

1. Piston reaches bottom of cylinder and exhaust valve opens
2. Piston travels up cylinder, forcing burned gases out of cylinder and into exhaust manifold

OBJECTIVE 6

Answers will vary

OBJECTIVE 8

a. 4
b. 2
c. 1, 2, 3
d. 2, 3, 4
e. 1
f. 2, 4
g. 2, 3, 4,
h. 2, 4
i. 2, 3
j. 1, 2
k. 3
l. 4
m. 1, 4
n. 4

OBJECTIVE 9

a. Engine location — Front
Drivetrain design — Four-wheel-drive

b. Engine location — Front
Drivetrain design — Front-wheel-drive

OBJECTIVE SHEET

UNIT B-1 USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

INTRODUCTION

There are well over 170 million vehicles in service in the United States today. They come in many different styles, equipped with various engines and other components, made by several manufacturers in and outside this country, and have changed every year—and sometimes more often—since roughly the turn of the century. It would be impossible for anyone to memorize all that there is to know about every part, tool, and procedure required to service such a wide array of vehicles. As a result, service specialists must be able to use the various reference materials that are needed to provide the information required to perform automotive service. The information and skills covered in this unit can help the student learn to use automotive service reference materials.

UNIT OBJECTIVE

After completing this unit, the student should be able to use automotive service reference materials. The student will demonstrate these competencies by completing the assignment sheets, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit A-5, "Study Automotive Design."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with automotive service reference materials by choosing the correct definition from a list of four choices.

2. Determine reference materials that can be used as the source for specific information by indicating each reference in a list that could be used for a given situation.

3. Interpret vehicle identification numbers. (Assignment Sheet 1)
4. Interpret illustrations used in automotive service reference materials. (Assignment Sheet 2)
5. Interpret graphs used in automotive service reference materials. (Assignment Sheet 3)
6. Interpret diagrams used in automotive service reference materials. (Assignment Sheet 4)
7. Interpret tables used in automotive service reference materials. (Assignment Sheet 5)
8. Use reference materials to answer specific questions. (Assignment Sheet 6)
9. Master troubleshooting concepts. (Assignment Sheet 7)
10. Replace fuses. (Job Sheet 1)
11. Replace wiper blades. (Job Sheet 2)
12. Troubleshoot a vehicle that will not start. (Job Sheet 3)

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SUGGESTED ACTIVITIES	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstrations of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Display posters, charts, safety signs, etc., that emphasize illustrations, tables, and reference materials. Display various types of reference materials.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss introduction to the unit (see Objective Sheet).

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive service specialist. Also relate the objective to your intoduction and to materials previously covered.

- Display various types of reference materials.
- Use work orders and service procedures to demonstrate the need for various resources in determining parts, specifications, and other information.
- Emphasize how reference materials are useful and necessary tools. Discuss Supplement 1, "Purpose of Illustrations in Automotive Service Reference Materials."

Objective 1 Recognize definitions of terms associated with automotive service reference materials

- Show examples of both types of specifications.
- Have the class give examples of makes, models, and families of vehicles.
- Use new car brochures to show lists of options and to distinguish between standard and optional equipment.
- Have the class give examples of domestic and imported vehicles.

Objective 2 Determine reference materials that can be used as the source for specific information

- Use each type of reference material when discussing the various types.
- Point out the organization and features of each type of resource used in your shop. Discuss Student Supplement 1, "Organization of Reference Materials."
- Emphasize the differences among the materials and the primary purpose of each. Give examples of situations in which each type is used.
- Emphasize how the students will have to rely upon reference materials throughout their careers.
- Explain to students how the flat-rate manual is used, and point out that information from flat-rate manuals and parts guides are sometimes combined in a single manual.

Objectives 3-9

- Explain the purpose and use of a vehicle identification number (VIN), and have students complete Assignment Sheet 1, "Interpret Vehicle Identification Numbers."

- Use Transparencies 1 through 7 to discuss types of illustrations. Have students read Student Supplement 2, "Interpreting Illustrations," and complete Assignment Sheet 2, "Interpret Illustrations Used in Automotive Service Reference Materials."

- Use Transparency 8, "Parts of a Graph," to explain the use of graphs. Have students read Student Supplement 3, "Interpreting Graphs," and complete Assignment Sheet 3, "Interpret Graphs Used in Automotive Service Reference Materials."

- Use Transparencies 9 through 12 to discuss types of diagrams. Have students read Student Supplement 4, "Interpreting Diagrams," and complete Assignment Sheet 4, "Interpret Diagrams Used in Automotive Service Reference Materials."

- Use Transparency 13 to explain the use of tables. Have students read Student Supplement 5, "Interpreting Tables," and complete Assignment Sheet 5, "Interpret Tables Used in Automotive Service Reference Materials."

- Discuss Assignment Sheets 1 through 5 in class when students have completed. Have students complete Assignment Sheet 6, "Use Reference Materials to Answer Specific Questions."

- Have students read Student Supplement 6, "Troubleshooting," and complete Assignment Sheet 7, "Master Troubleshooting Concepts." Discuss in class.

Objectives 10-12

- Discuss equipment and materials used in each job sheet. Review with students applicable safety rules and precautions and the guidelines given in each job-sheet introduction.

- Discuss the proper use of a work order, and provide students with copies of Supplement 2, "Sample Work Order," or your own work order to use when practicing procedure sheets.

- Demonstrate Job Sheets 1 through 3, Have students practice Job Sheets 1 through 3 until they are ready to take the practical tests.

Unit summary activity

- Discuss Activity Sheet 1, "Report on Service Bulletins." The purpose of this activity is to provide students with the opportunity to study service bulletins and to write a report or to report to the class so that students will not only become familiar with service bulletins but also improve writing or speaking, organizational, and interpersonal skills. Keep this in mind when discussing the assignment.

- Have students complete Activity Sheet 1.

EVALUATION

- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Armstrong, Ivan J. *Auto Mechanics, Volume 1.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1976.
- Armstrong, Ivan J. *Auto Mechanics, Volume II.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1978.
- *Basic Car Care Illustrated,* 2nd ed. New York: The Hearst Corporation, 1980.
- *Chevrolet 10-30 Series 1984 Light Duty Truck Shop Manual.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1984.
- *Chevrolet 10-30 Series 1985 Light Duty Truck Shop Manual.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1984.
- *Chevrolet 10-30 Series 1986 Light Duty Truck Shop Manual.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1985.
- *Chilton's Auto Repair Manual, 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.
- Crouse, William H. and Donald L. Anglin. *Automotive Body Repair and Refinishing,* 2nd ed. New York: Gregg Division, McGraw-Hill Book Company, 1986.
- Crouse, William H. and Donald L. Anglin. *Automotive Mechanics,* 9th ed. New York: Gregg Division, McGraw-Hill Book Company, 1985.
- Crouse, William H. and Donald L. Anglin. *Automotive Transmissions and Power Trains,* 5th ed. New York: Gregg Division, McGraw-Hill Book Company, 1976.
- Crouse, William H. and Donald L. Anglin, *The Auto Book,* 3rd ed. New York: Gregg Division, McGraw-Hill Book Company, 1984.

- de Kryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- Mitchell Information Services, Inc. *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Mitchell Tech Service Bulletins: Repair,* 1985 ed. San Diego, California: Mitchell Information Services, Inc., 1985.
- *Motor Auto Repair Manual 1982.* New York: The Hearst Corporation, 1981.
- *Motor Parts and Time Guide 1982.* New York: The Hearst Corporation, 1981.
- *1980 Chrysler Service Manual: Trucks D150-400, Dodge Ramcharger, Plymouth Trail Duster.* Centerline, Michigan, 1980.
- *1980 Ford Car Shop Manual: Body, Chassis, Electrical.* Dearborn, Michigan: Ford Motor Company, 1979.
- *1980 Ford Car Shop Manual: Powertrain.* Dearborn, Michigan: Ford Motor Company, 1979.
- *1985 Chrysler Engine/Chassis/Body Service Manual: 1985 Front Wheel Drive Passenger Vehicles Lancer, LeBaron GTS, Daytona, Laser, New Yorker, LeBaron, Dodge 600, Aries, Reliant, Omni, Horizon.* Centerline, Michigan: Chrysler Corporation, 1984.
- *1986 Chevrolet Shop Manual: Caprice, Monte Carlo, and El Camino.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1985.
- *1986 Chrysler Engine/Chassis/Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corporation, 1985.
- *Pontiac 1985 Preliminary Service Information: Grand Am.* General Motors Corporation, Pontiac Motor Division, 1984.
- Stockel, Martin W. and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.

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- Thomas, T. A. *Technical Illustration.* New York: McGraw-Hill Book Company, 1968.

Resources to be used as student references

NOTE: The materials listed below were used as resources in preparing assignment sheets, written test, and other components that require information and specifications for specific makes and models of vehicles. Copies of these materials may be required by students in completing such assignments.

- *1986 Shop Manual: Caprice, Monte Carlo,* and *El Camino.* Warren, Michigan: General Motors Corporation, Chevrolet Motor Division, 1985.
- *Chevrolet 10-30 Series 1986 Light Duty Truck Shop Manual.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1985.
- *Chilton's Auto Repair Manual, 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.
- *1980 Chrysler Service Manual: Trucks D150-400, Dodge Ramcharger, Plymouth Trail Duster.* Centerline, Michigan, 1980.
- *1980 Ford Car Shop Manual: Body, Chassis, Electrical.* Dearborn, Michigan: Ford Motor Company, 1979.
- *1980 Ford Car Shop Manual: Powertrain.* Dearborn, Michigan: Ford Motor Company, 1979.
- *1986 Chrysler Engine/Chassis/Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle Reliant, Horizon.* Centerline, Michigan: Chrysler Corporation, 1985.
- Mitchell *Tech Service Bulletins, 1985.* San Diego, California: Mitchell Manuals, 1985.
- *Motor Parts and Time Guide, 1982.* New York: The Hearst Corporation, 1981.

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Media

NOTE: Media to support this unit is available from a variety of sources. Some media dealing with the use of reference materials in general has been developed, such as the filmstrip "Using Shop Manuals and Purchasing Parts" in the Prentice-Hall series *General Auto Mechanic: Basic Skills*. Other programs are available from resource materials producers, such as vehicle manufacturers and companies that produce specialty items, such as microfiche files. Additional media may be available from other training programs in your school, such as drafting courses which may have useful media on types of illustrations and the alphabet of lines. You will have to review such material carefully to determine whether it will be helpful without going beyond what your students need to study.

Print media

- Brochures, pamphlets, and charts

  NOTE: Vehicle, equipment, and aftermarket manufacturers have brochures, posters, and other materials available that use a variety of illustrations and tables. Many of these would be suitable as displays during study in this unit.

- Transparencies and competency profiles

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

INSTRUCTOR'S SUPPLEMENTS	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

SUPPLEMENT 1

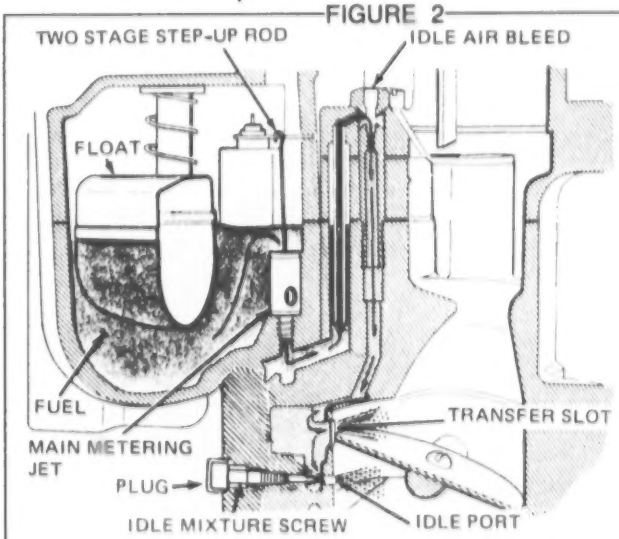
Purposes of Illustrations in Automotive Service Reference Materials

Presentation illustration — Gives an artistic view; used primarily to make a vehicle, portion of vehicle, or component attractive (Figure 1)

FIGURE 1

Operations illustration — Shows how something functions or how a procedure is to be done (Figures 2 and 3)

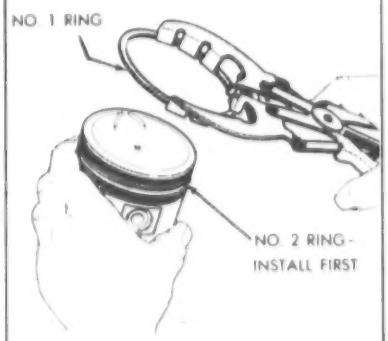
FIGURE 2



Low-speed system in operation in a carburetor

Used with permission of Chrysler Corporation.

FIGURE 3

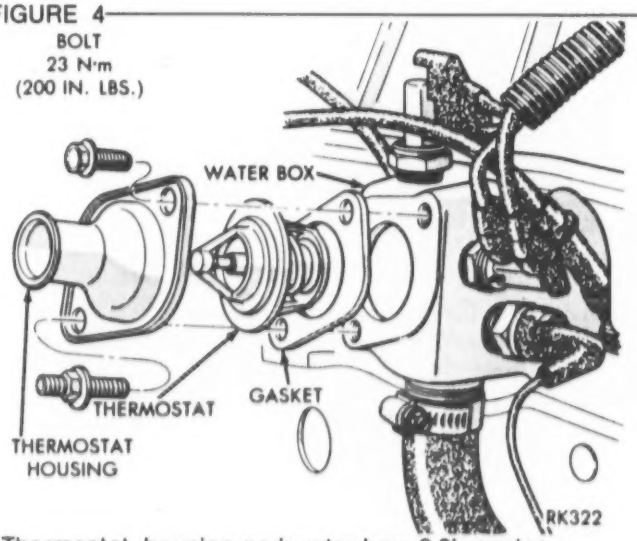


Installing upper and intermediate rings

Used with permission of Chrysler Corporation.

Installation illustration — Shows the relationship of parts or components to each other (Figure 4)

FIGURE 4



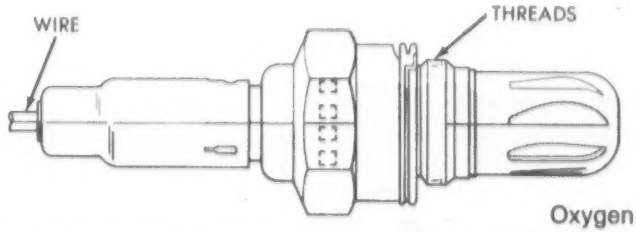
Thermostat, housing and water box, 2.2L engine

Used with permission of Chrysler Corporation.

Information illustration — Provides information or data or illustrates an example to support a description in the text (Figure 5)

FIGURE 5

Use Tool C-4589 to remove the sensor. The threads in the exhaust manifold must be cleaned with a 18 mm × 1.5 × 6E tap. If the same sensor is to be reinstalled, the threads must be coated with an anti-seize compound such as Loctite 771-64 or equivalent. New sensors are packaged with anti-seize compound on the threads and no additional compound is required. Sensors must be torqued to 27 N·m (20 ft. lbs.).



Oxygen sensor

Used with permission of Chrysler Corporation.

SUPPLEMENT 2 Sample Work Order

PARTS_____TIRES_____BATTERIES_____ACCESSORIES

QTY.	PART NO.	DESCRIPTION	UNIT	EST. AMOUNT		ACTUAL AMOUNT	
		TOTAL PARTS					
		OUTSIDE REPAIRS					
		TOTAL OUTSIDE REPAIRS					

NOT RESPONSIBLE FOR LOSS OR DAMAGE TO CAARS OR ARTICLES LEFT IN CARS IN CASE OF FIRE, THEFT, OR ANY OTHER CAUSE BEYOND OUR CONTROL.

REPAIRS PERFORMED BY

SIGNATURES OF MECHANICS
1 _____
2

YOU ARE ENTITLED BY LAW TO THE RETURN OF ALL PARTS REPLACED, EXCEPT THOSE WHICH ARE TOO HEAVY OR LARGE, AND THOSE REQUIRED TO BE SENT BACK TO THE MANUFACTURER OR DISTRIBUTOR BECAUSE OF WARRANTY WORK OR AN EXCHANGE AGREEMENT. YOU ARE ENTITLED TO INSPECT THE PARTS WHICH CANNOT BE RETURNED TO YOU.

AUTHORIZED INCREASE IN ESTIMATE BY: $ _____ APPROVED PER: _____

YOU ARE ENTITLED TO A COPY OF THIS ORDER AT THE TIME OF YOUR SIGNATURE.

I hereby authorize the above repair work to be done along with the necessary material and hereby grant you and/or your employee permission to operate the car, truck, or vehicle herein described on streets, highways, or elsewhere for the purpose of testing and/or inspection.

X _____

Terrific Auto Service
555 Main Street
Hometown, Oklahoma 48910

State Registration No. F 100000

Waiver Signed ☐ ☐

NAME _____ DATE _____

ADDRESS _____ PHONE _____

YEAR AND MAKE	TYPE OF MODEL	MOTOR NO.	SERIAL NO.

SPEEDOMETER	LICENSE	PROMISED	PHONE WHEN READY YES NO

SERVICES TO BE PERFORMED	UNIT	EST. AMOUNT		ACTUAL AMOUNT	

Gasoline • Oil • Grease	EST. AMOUNT		ACTUAL AMOUNT	
GALS GAS @				
QTS OIL @				
TRANS/DIFF @				
ATF @				
TOTAL				

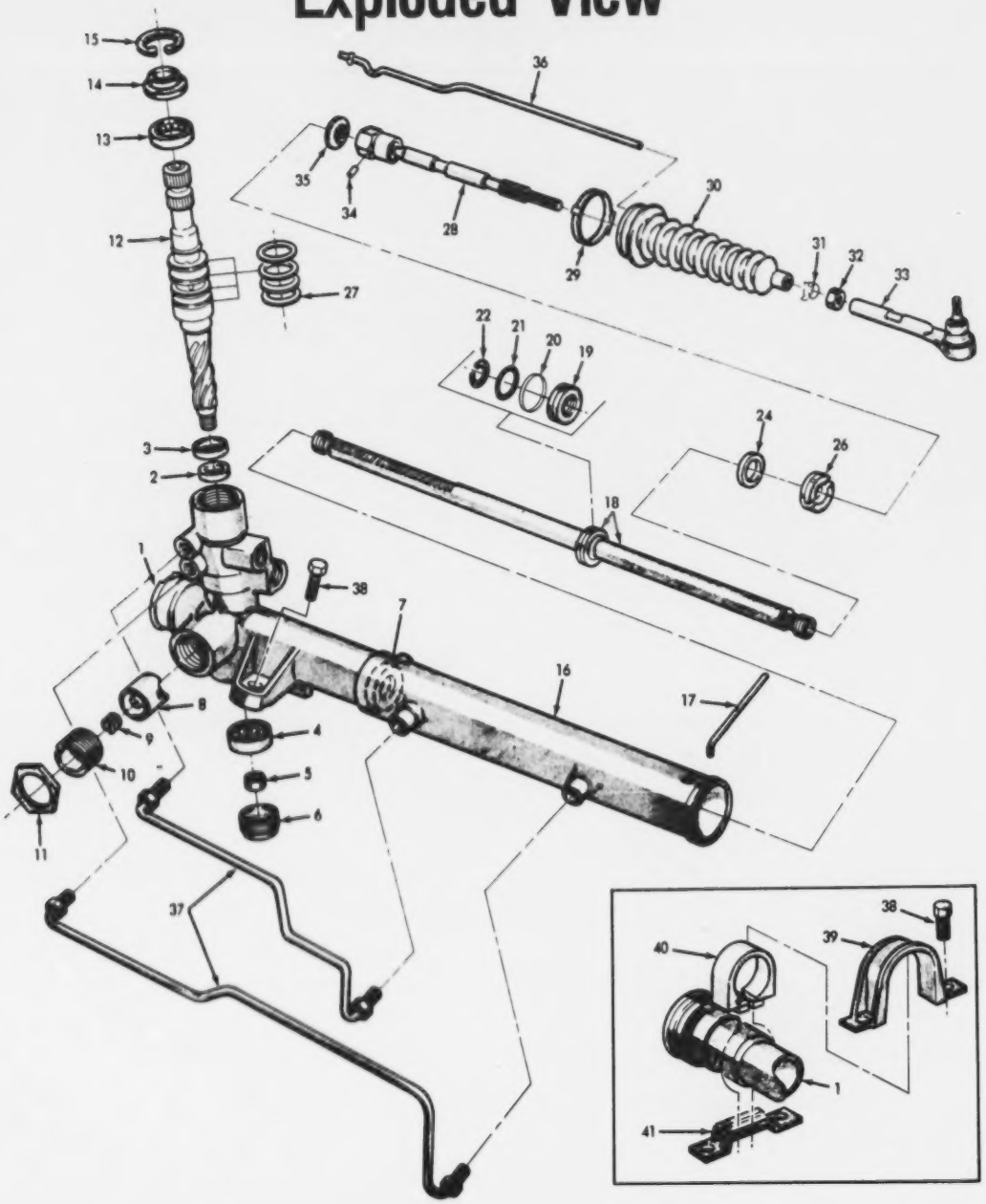
— CERTIFICATION —

Above repairs properly performed

X

TOTAL LABOR				
TOTAL PARTS				
TOTAL GAS, OIL AND GREASE				
OUTSIDE REPAIR				
OTHER				
SUB TOTAL				
SALES TAX				
TOTAL				

Exploded View

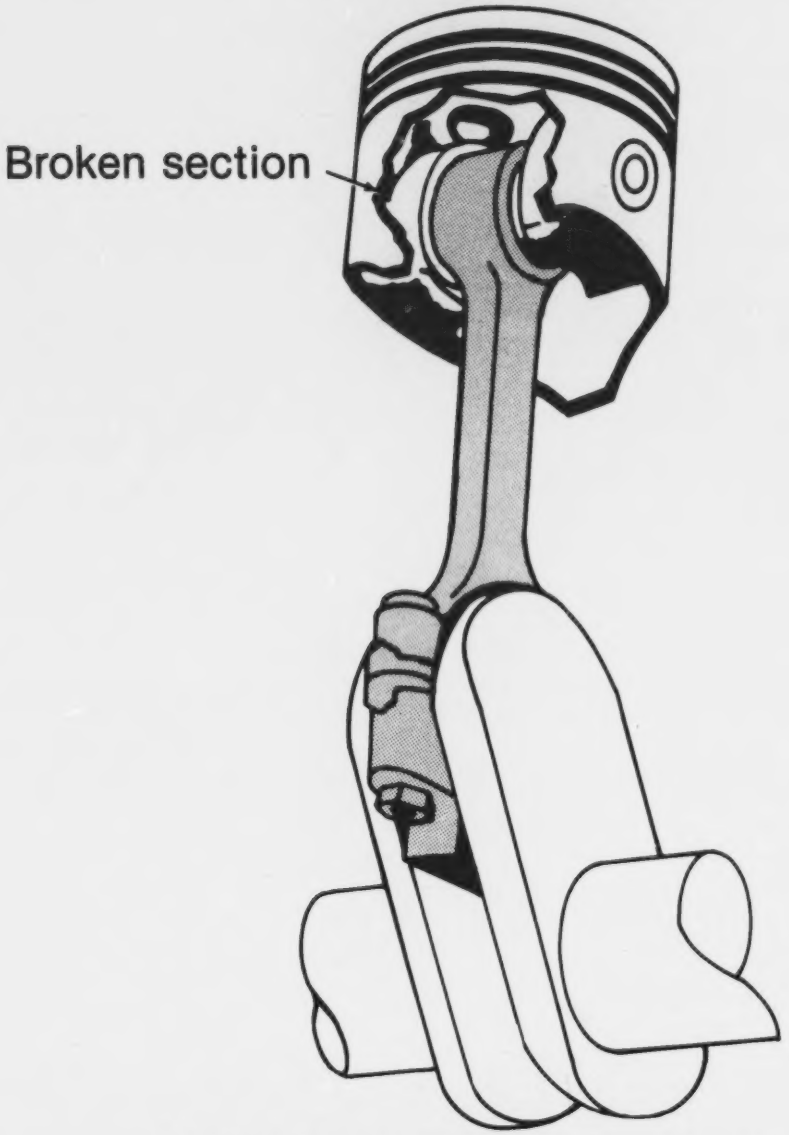


TRW power steering gear

Used with permission of Chrysler Corporation.

Cross-Sectional View

Broken Representation

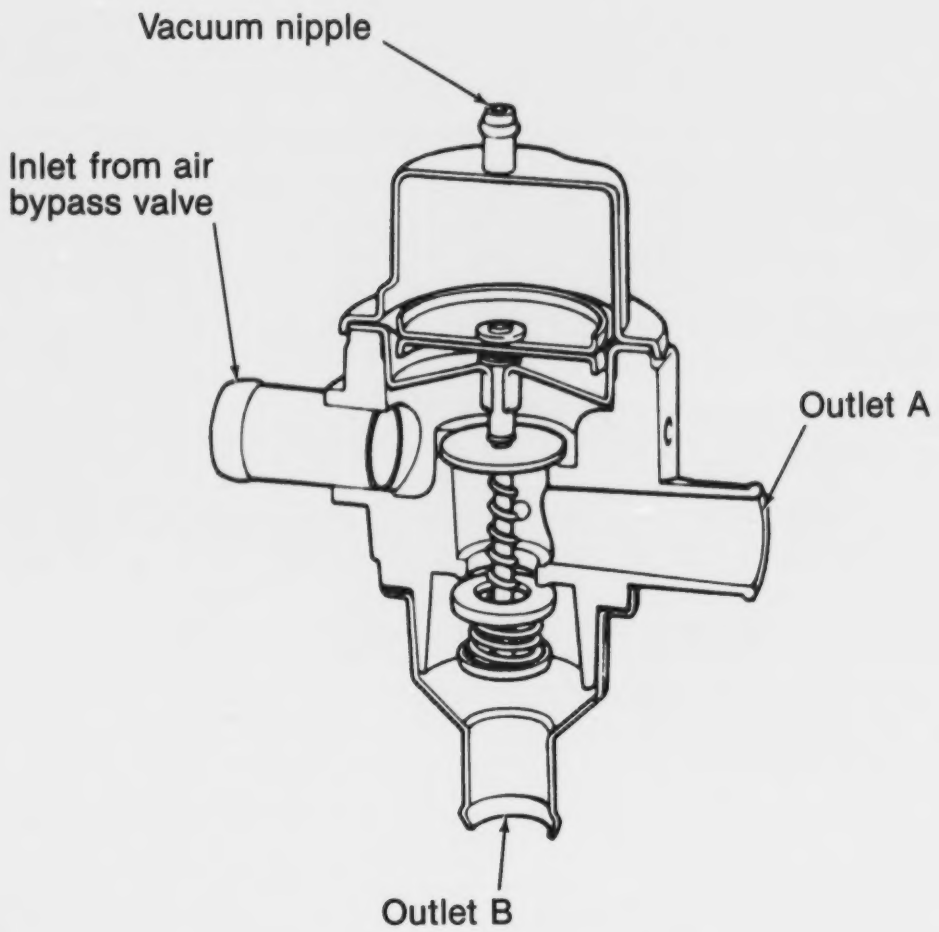


Piston-and-connecting-rod assembly attached to the crankpin on the crankshaft.

Reprinted with permission of McGraw-Hill Book Company, from *The Auto Book*, 3rd ed., by William H. Crouse and Donald L. Anglin, 1984.

Cross-Sectional View (Continued)

Cutaway Representation

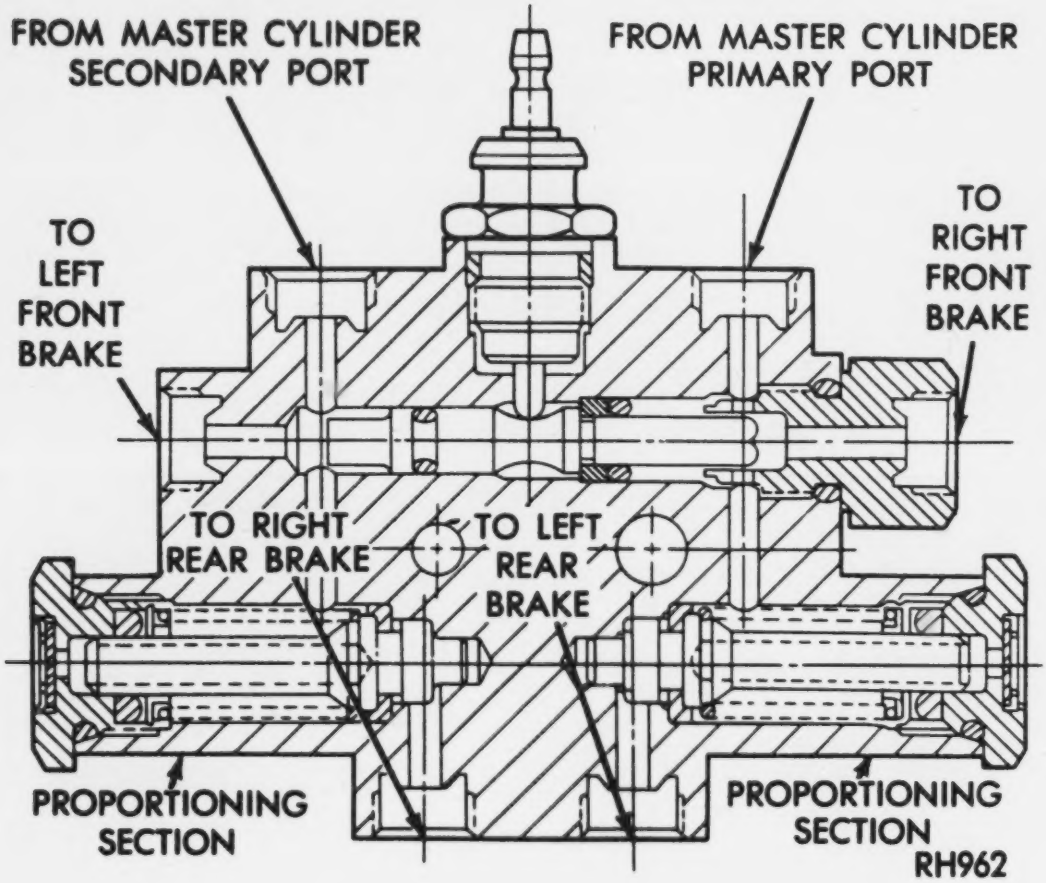


Standard air control valve

Used with permission of Ford Motor Company.

Cross-Sectional View
(Continued)

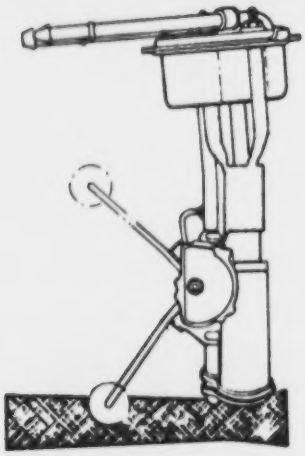
Mechanical Drawing Representation



Switch and Valve Assembly

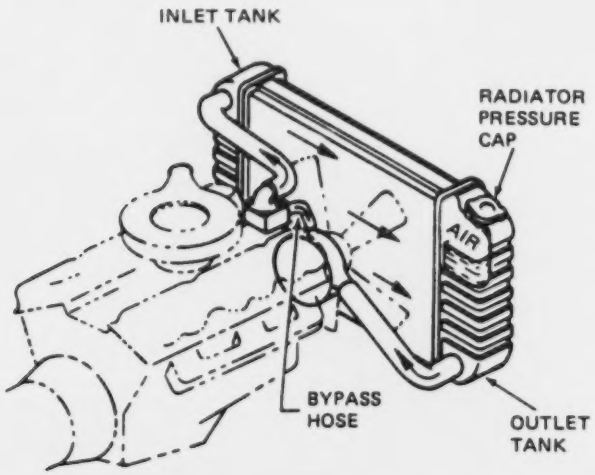
Used with permission of Chrysler Corporation.

Phantom Views



Phantom position

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

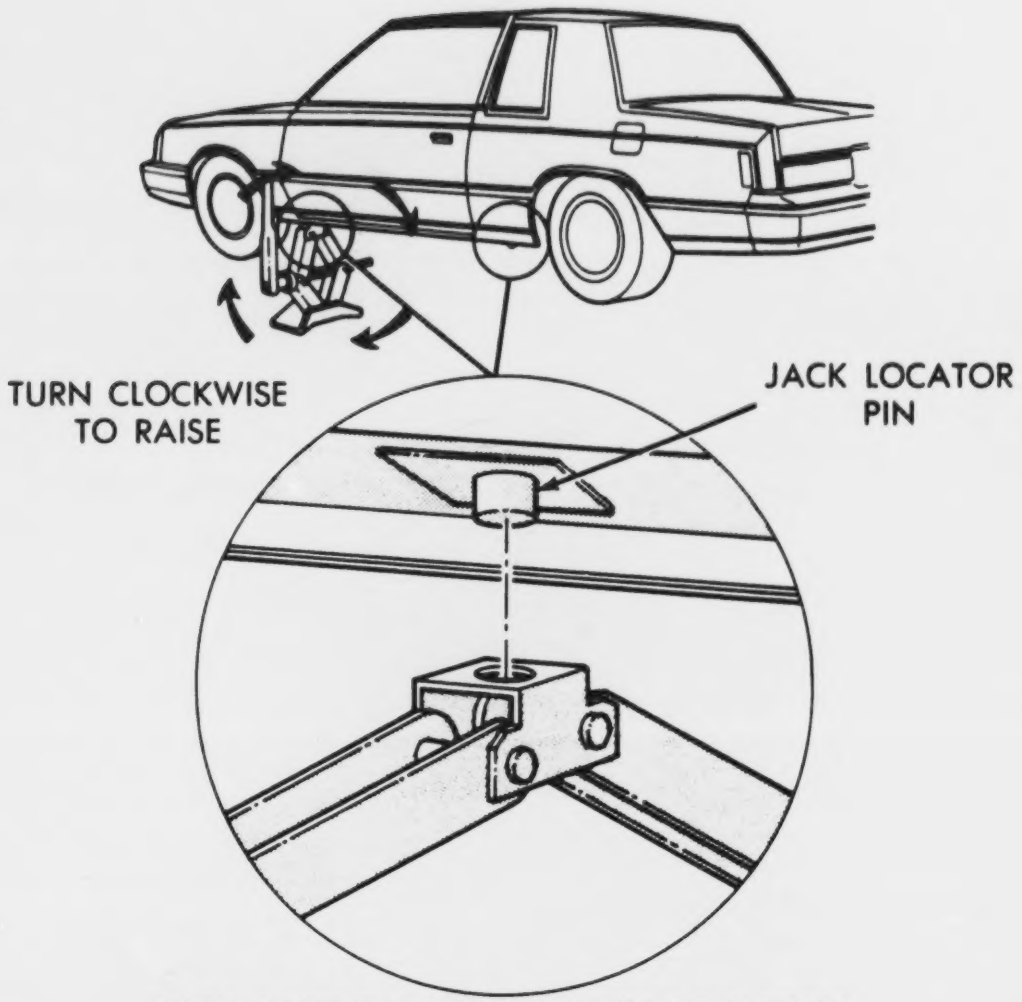


Cooling system using a cross-flow radiator.

Phantom lines to show detail

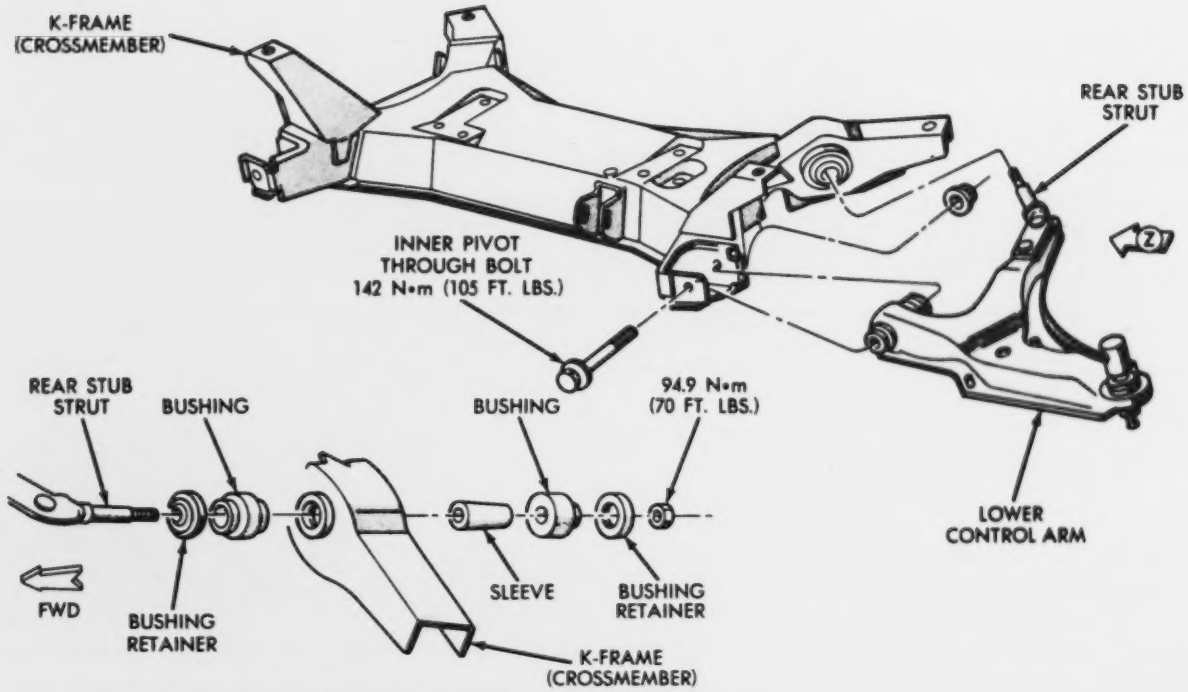
Reprinted with permission of General Motors Corporation, Harrison Radiator Division copyright © 1985.

Detail View



Used with permission of Chrysler Corporation.

Auxiliary View

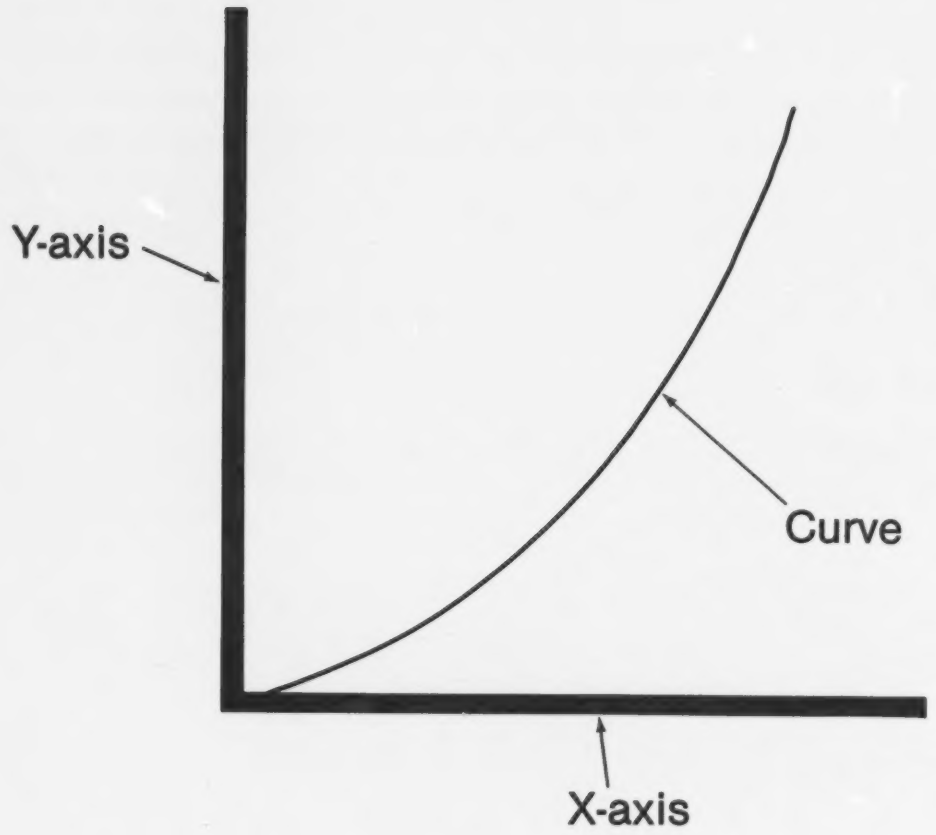


VIEW IN DIRECTION OF ARROW Z

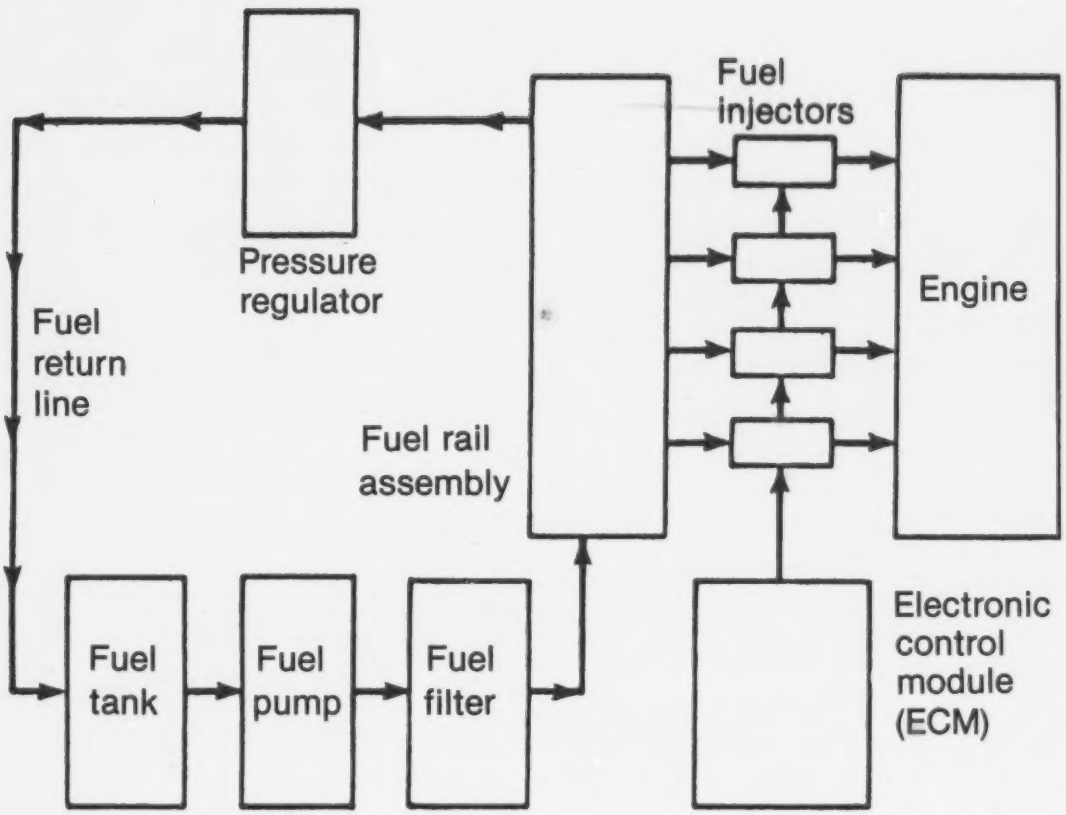
Lower Control Arm Assembly

Used with permission of Chrysler Corporation.

Parts of a Graph



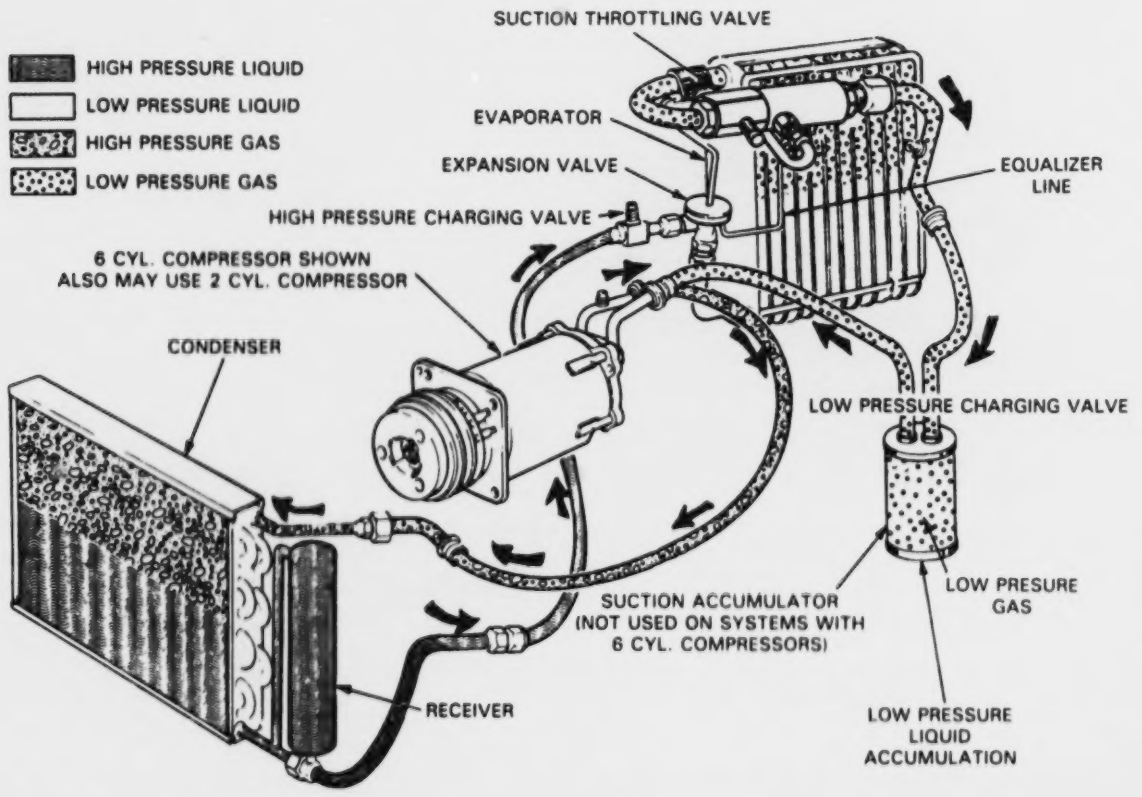
Block Diagram



Sequential fuel injection system

Used with permission of General Motors Corporation, Buick Motor Division.

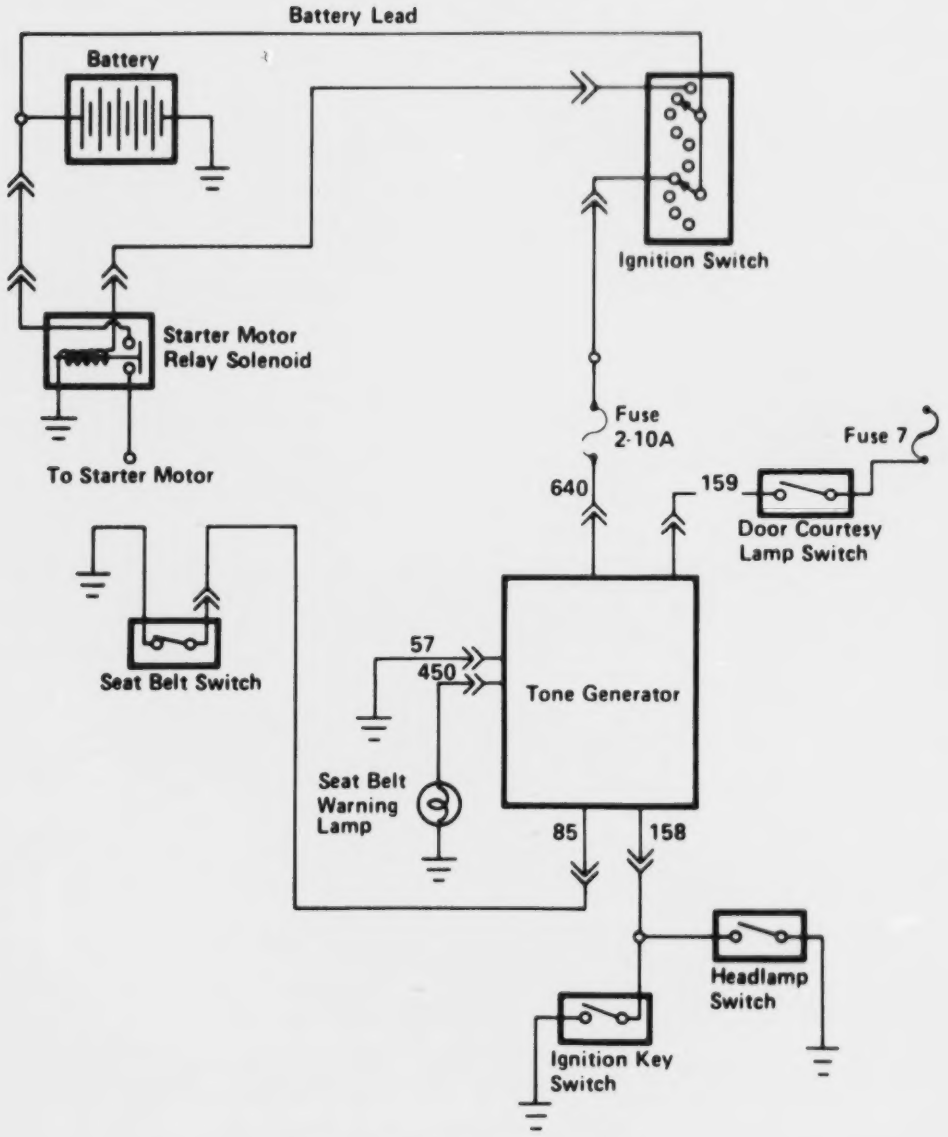
Pictorial Diagram



Trace flow of liquid and vapor R-12 through system. Also note location of accumulator.

Used with permission of Ford Motor Corporation.

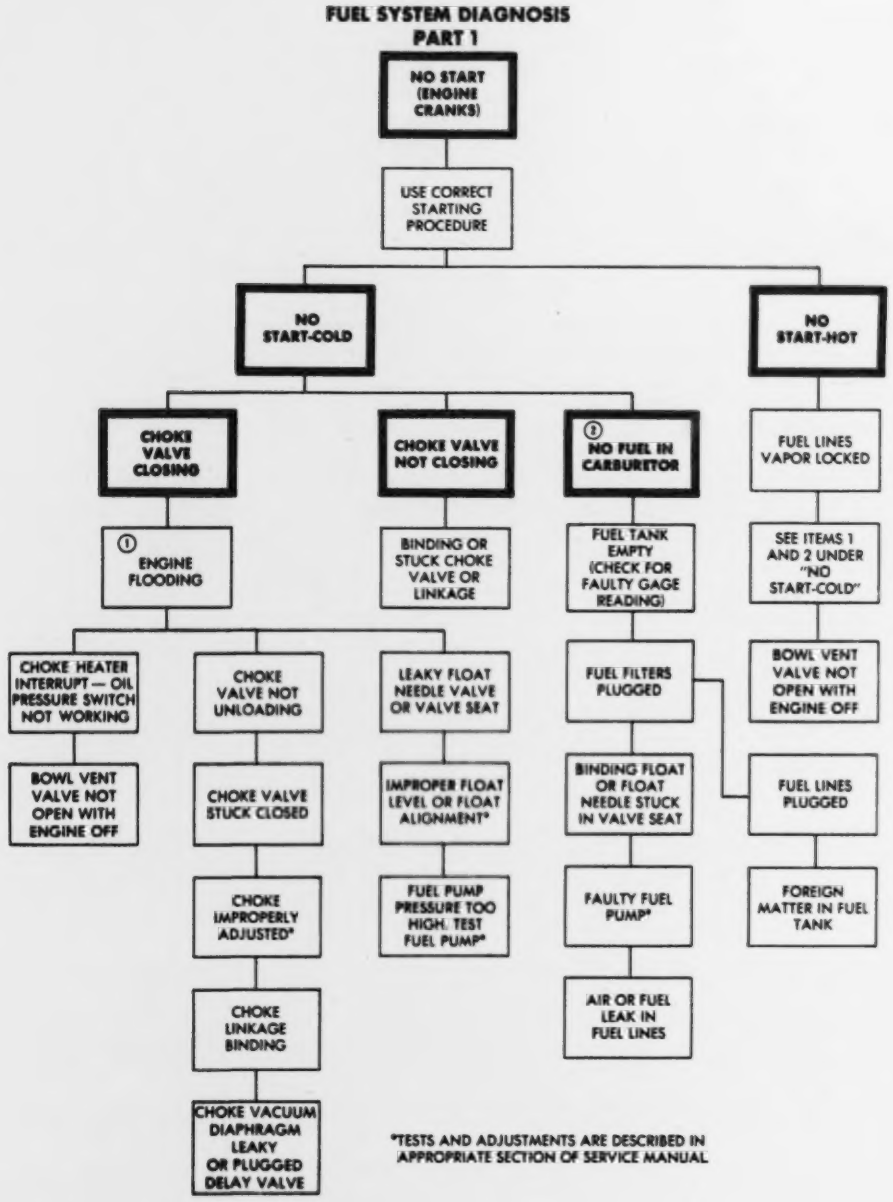
Schematic Diagram



Tone generator warning system.

Used with permission of Ford Motor Company.

Flow Diagram


FUEL SYSTEM DIAGNOSIS
PART 1
NO START (ENGINE CRANKS)
USE CORRECT STARTING PROCEDURE
NO START-COLD
NO START-HOT
CHOKE VALVE CLOSING
CHOKE VALVE NOT CLOSING
② NO FUEL IN CARBURETOR
FUEL LINES VAPOR LOCKED
① ENGINE FLOODING
BINDING OR STUCK CHOKE VALVE OR LINKAGE
FUEL TANK EMPTY (CHECK FOR FAULTY GAGE READING)
SEE ITEMS 1 AND 2 UNDER "NO START-COLD"
CHOKE HEATER INTERRUPT — OIL PRESSURE SWITCH NOT WORKING
CHOKE VALVE NOT UNLOADING
LEAKY FLOAT NEEDLE VALVE OR VALVE SEAT
FUEL FILTERS PLUGGED
BOWL VENT VALVE NOT OPEN WITH ENGINE OFF
BOWL VENT VALVE NOT OPEN WITH ENGINE OFF
CHOKE VALVE STUCK CLOSED
IMPROPER FLOAT LEVEL OR FLOAT ALIGNMENT*
BINDING FLOAT OR FLOAT NEEDLE STUCK IN VALVE SEAT
FUEL LINES PLUGGED
CHOKE IMPROPERLY ADJUSTED*
FUEL PUMP PRESSURE TOO HIGH. TEST FUEL PUMP*
FAULTY FUEL PUMP*
FOREIGN MATTER IN FUEL TANK
CHOKE LINKAGE BINDING
AIR OR FUEL LEAK IN FUEL LINES
CHOKE VACUUM DIAPHRAGM LEAKY OR PLUGGED DELAY VALVE
*TESTS AND ADJUSTMENTS ARE DESCRIBED IN APPROPRIATE SECTION OF SERVICE MANUAL

Used with permission of Chrysler Corporation.

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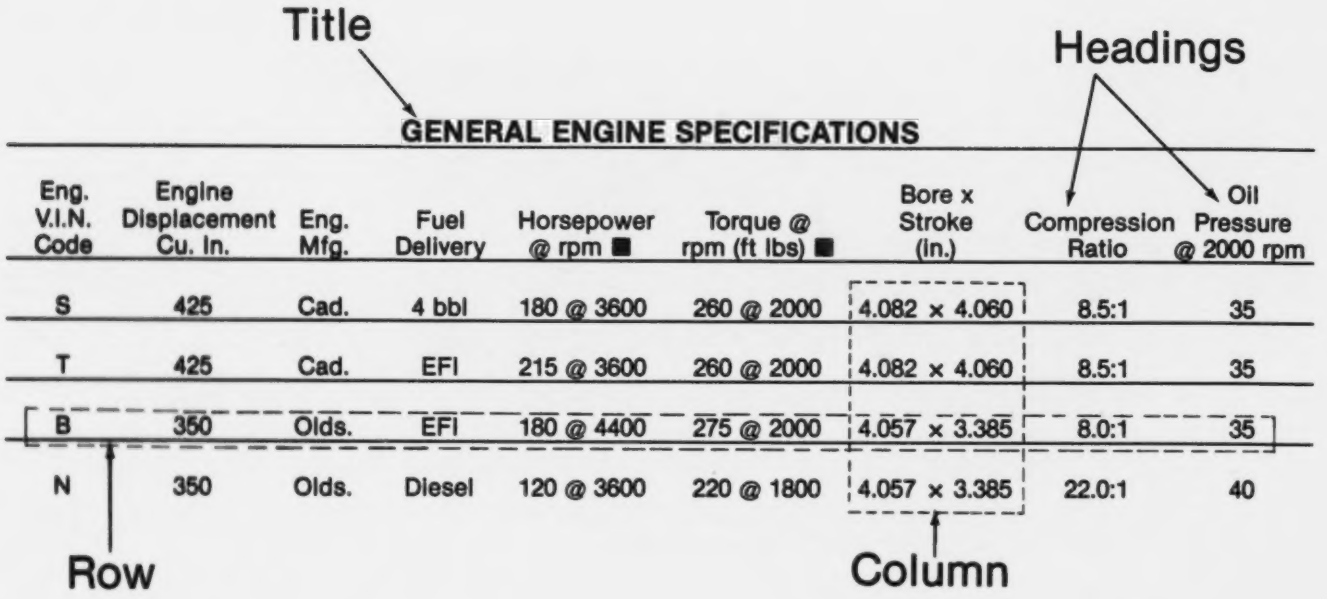
Parts of a Table



Eng. V.I.N. Code	Engine Displacement Cu. In.	Eng. Mfg.	Fuel Delivery	Horsepower @ rpm ■	Torque @ rpm (ft lbs) ■	Bore x Stroke (in.)	Compression Ratio	Oil Pressure @ 2000 rpm
S	425	Cad.	4 bbl	180 @ 3600	260 @ 2000	4.082 x 4.060	8.5:1	35
T	425	Cad.	EFI	215 @ 3600	260 @ 2000	4.082 x 4.060	8.5:1	35
B	350	Olds.	EFI	180 @ 4400	275 @ 2000	4.057 x 3.385	8.0:1	35
N	350	Olds.	Diesel	120 @ 3600	220 @ 1800	4.057 x 3.385	22.0:1	40

Adapted from *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

PRETEST ANSWERS

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

EVALUATOR NOTE

Use the answer key on the next page to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 2, 27
2	3, 4, 28
3	21, 22, 23
4	5, 6, 7, 8, 9
5	10, 12, 29
6	11, 13, 30
7	14, 15
8	16, 17, 18, 19, 20
9	31, 32, 33
10	24, 25
11	26
12	31, 32, 33

ANSWER KEY

1. b
2. d
3. d
4. a
5. d
6. b
7. a
8. b
9. a
10. c
11. a
12. b
13. b
14. d
15. c
16. b
17. c
18. a
19. d
20. a
21. d
22. a
23. c
24. d
25. a
26. a
27. b
28. c
29. c
30. c
31. d
32. d
33. a

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PRETEST

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

Name _____ Score _____

DIRECTIONS Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. The best definition for *make of vehicle* is

   a. The year in which a vehicle is manufactured
   b. Identification of a vehicle according to its manufacturer, name, and special designations
   c. The designated year of manufacture set by the company; this date may be different from the actual calendar year
   d. Identification of a vehicle according to its assembly plant, engine size, type of drive train, and other features

2. Which of the following is an example of an *illustration*?

   a. Drawing
   b. Photograph
   c. Diagram
   d. All of the above

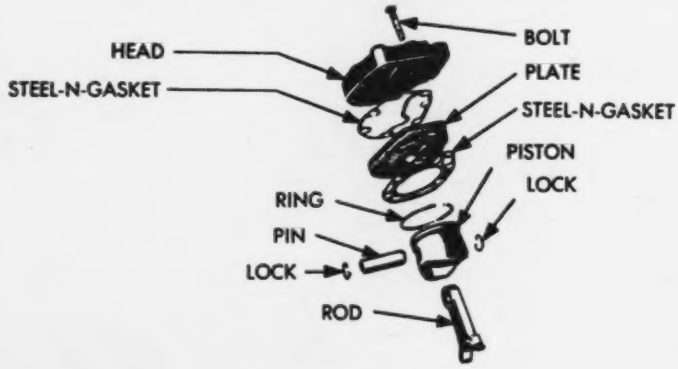
3. The major purpose of a service bulletin is to

   a. Show the interchangeability of parts
   b. Give the approximate reasonable time required for a service procedure
   c. Provide service procedures and specifications for the vehicles of various manufacturers produced during a period of several years
   d. Update information or procedures for a specific vehicle, family of vehicles, tool, part, or equipment

4. All of the following materials are likely to recommend service intervals for a vehicle **except**

   a. Flat-rate manual
   b. Service manual
   c. Owner's manual
   d. Professional manual

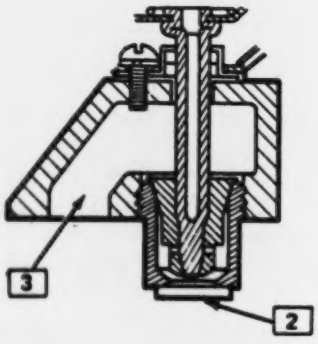
5. The following illustration is called an



Used with permission of Chrysler Corporation.

a. Extended view
b. Alignment diagram
c. Assembly chart
d. Exploded view

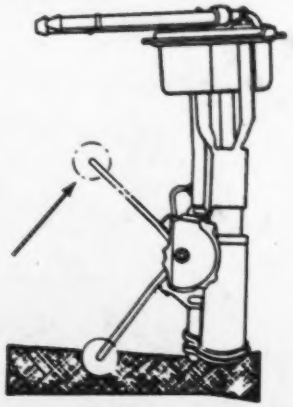
6. The purpose of the diagonal lines in the following illustration is to



Adapted with permission of General Motors Corporation, Chevrolet Motor Division.

a. Designate the colors of the various parts
b. Distinguish among separate parts
c. Give the drawing more visual appeal
d. Show how much of the part is being indicated by each arrow

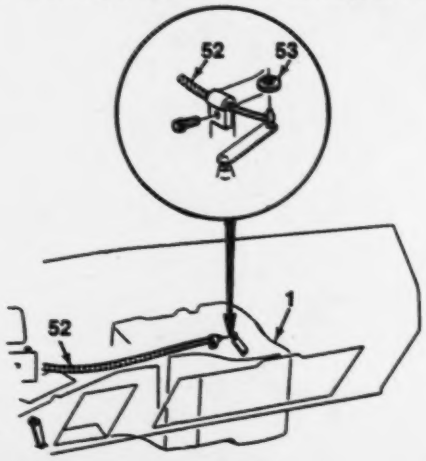
7. The reason for showing with broken lines the part of the following drawing indicated by the arrow is to show that the part



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

a. May sometimes be in that position
b. Is made of glass or plastic
c. Is no longer placed in the position shown on this vehicle
d. Is an option on this vehicle

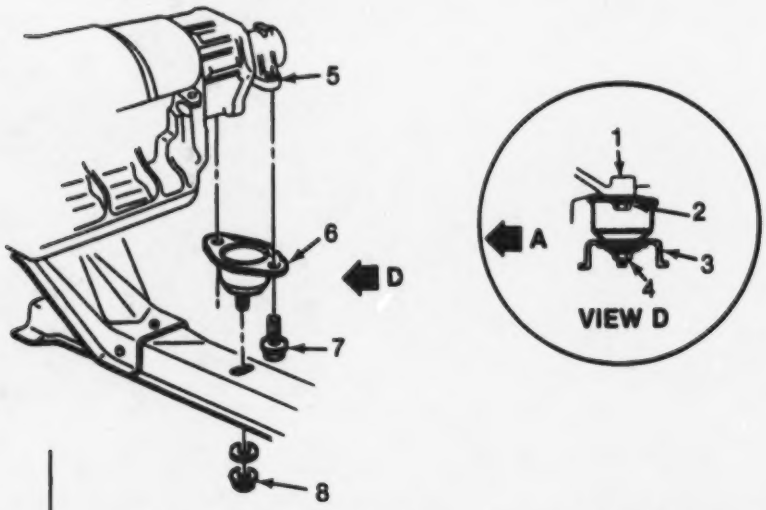
8. The circled portion of the following illustration is used to show



Adapted with permission of General Motors Corporation, Chevrolet Motor Division.

a. The difference between part 52 and 53
b. A more detailed view of the area indicated by the large arrow
c. The use of an optional design
d. What the opposite end of part 52 looks like

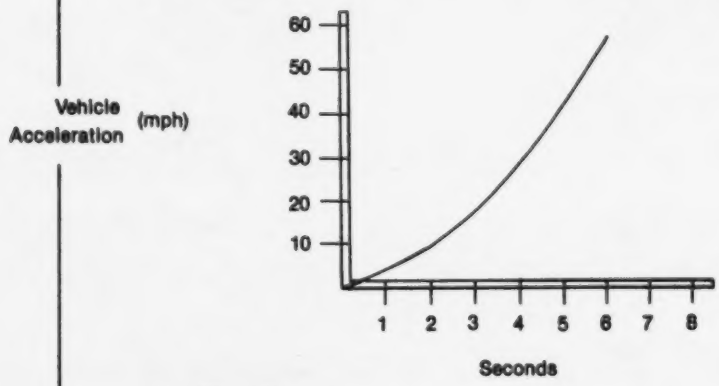
9. In the illustration below, some of the parts in the large drawing are the same as those in the circled portion. Choose the pair of numbers that gives the correct match between numbered parts.



Used with permission of General Motors Corporation, Chevrolet Motor Division.

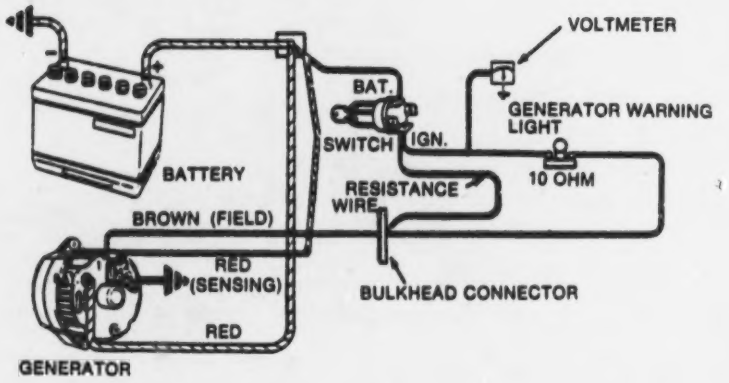
a. 1, 5
b. 3, 5
c. 2, 6
d. 4, 7

10. In the graph below, how fast is the vehicle going after 4 seconds?



a. 20 mph
b. 25 mph
c. 30 mph
d. 35 mph

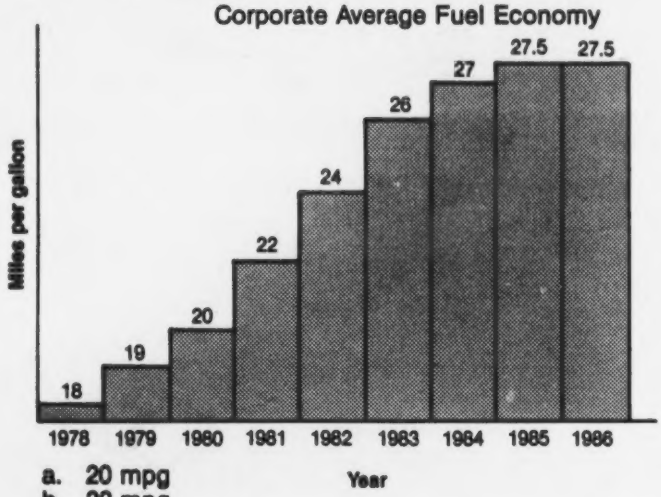
11. The pictorial diagram below shows that the generator warning light is connected to the generator by a



Used with permission of General Motors Corporation, Chevrolet Motor Division.

a. Brown field wire
b. Red sensing wire
c. Resistance wire
d. None of the above

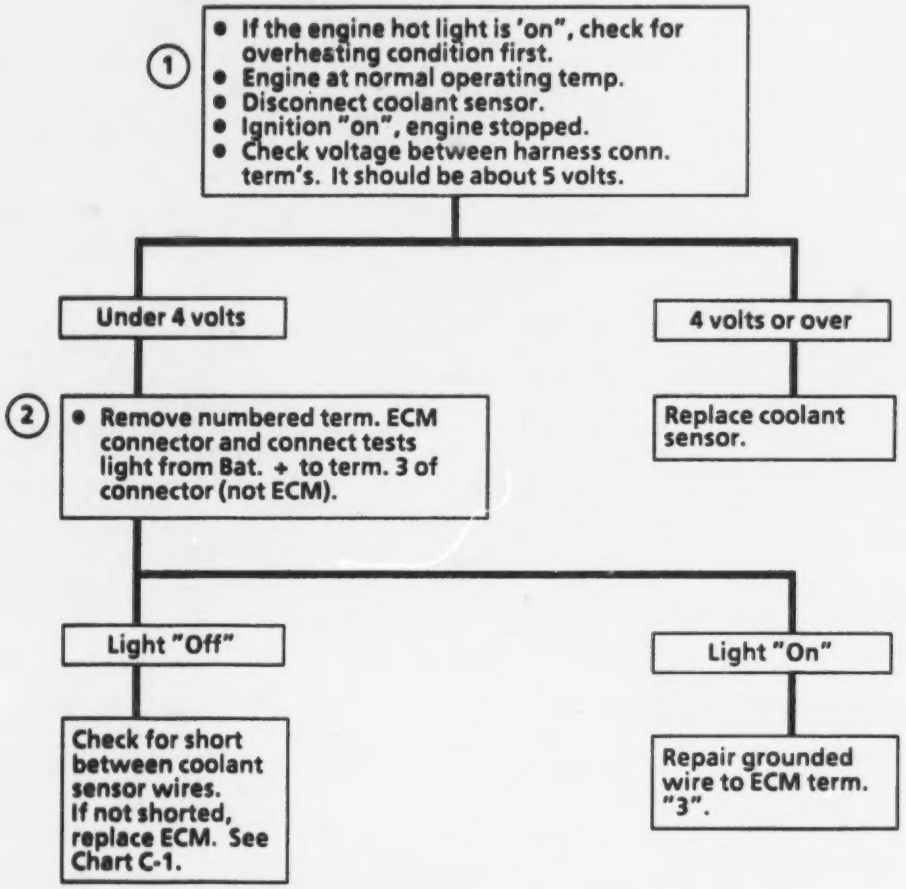
12. According to the following graph, the corporate average fuel economy for U.S.-manufactured vehicles during 1981 was approximately



a. 20 mpg
b. 22 mpg
c. 23 mpg
d. 24 mpg

13. The flow diagram below is used to check a coolant sensor circuit that has been shorted. Technician A says that if the voltage between the harness connection terminals is 4.7 volts, you should remove the numbered terminal ECM connector and connect a test light from the positive (+) terminal of the battery to terminal 3 of the connector. Technician B says that if the voltage is 4.7 volts, you should replace the coolant sensor.

Who is right?


1
• If the engine hot light is 'on", check for overheating condition first.
• Engine at normal operating temp.
• Disconnect coolant sensor.
• Ignition "on", engine stopped.
• Check voltage between harness conn. term's. It should be about 5 volts.
Under 4 volts
4 volts or over
2
• Remove numbered term. ECM connector and connect tests light from Bat. + to term. 3 of connector (not ECM).
Replace coolant sensor.
Light "Off"
Light "On"
Check for short between coolant sensor wires. If not shorted, replace ECM. See Chart C-1.
Repair grounded wire to ECM term. "3".

Used with permission of General Motors Corporation, Chevrolet Motor Division.

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

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14. According to the table below, the cooling system for a 6.2 liter, diesel-fueled vehicle should be serviced

Scheduled Maintenance Services For 6.2L Diesel-Fueled Vehicle

ITEM NO.	TO BE SERVICED	WHEN TO PERFORM Miles (kilometers) or Months, Whichever Occurs First	The services shown in this schedule up to 45,000 miles (75 000 km) are to be performed after 45,000 miles at the same intervals								
		MILES (000)	5	10	15	20	25	30	35	40	45
		KILOMETERS (000)	8	16	24	32	40	48	56	64	72
1	Engine Oil & Filter Change*	Every 5,000 Miles (8 000 km) or 12 Months	•	•	•	•	•	•	•	•	•
2	Chassis Lubrication	See Explanation for service intervals									
3	Exhaust Pressure Regulator Valve Inspection*	At 5,000 Miles (8 000 km), then every 15,000 Miles (24 000 km)	•		•			•			•
4	Engine Idle Speed Check*	At 5,000 Miles (8 000 km), then at 30,000 Miles (48 000 km)	•1					•1			
5	Crankcase Ventilation System Inspection*	Every 12 Months or 15,000 Miles (24 000 km)			•			•			•
6	Cooling System Service*	Every 24 Months or 30,000 Miles (48 000 km)						•			
7	Front Wheel Bearing Repack	Every 30,000 Miles (48 000 km)						•			

Used with permission of General Motors Corporation, Chevrolet Motor Division.

a. Every 24 months
b. Every 30,000 miles
c. Every 24 months or 30,000 miles after 47,500 miles
d. Either a or b, whichever occurs first

15. According to the table below, which of the following is not a possible cause of a "no drive in drive range" complaint?

TYPE 400 TRANSMISSION TROUBLE-DIAGNOSIS CHART

COMPLAINT	POSSIBLE CAUSE	CHECK OR CORRECTION
1. No drive in drive range	a. Low oil level	Leaks: porous casting, damaged seals, defective diaphragm in vacuum modulator
	b. Manual linkage maladjusted	Readjust
	c. Low oil pressure	Check filter O ring, filter for blockage, pump, pressure regulator, case porosity
	d. Forward clutch not applying	Piston cracked, seals damaged, plates burned, leak in feed circuit, clutch ball check stuck
	e. Roller clutch damaged	Check for broken spring or damaged cage
2. 1-2 shift at full throttle only	a. Detent switch sticking or defective	Replace
	b. Detent solenoid loose or sticking	Tighten, check gasket; replace if defective
	c. Valve body	Check for loose mount, defective gasket, stuck detent valve train, 3-2 valve sticking
	d. Case porosity	Repair, replace
3. First speed only; no upshift	a. Governor assembly	Governor valve sticking, drive gear loose
	b. Valve body	1-2 valve stuck, feed channel blocked, valve body leaking due to loose bolts, gasket defect

Adapted and reprinted with permission of McGraw-Hill Book Company, Gregg Division, from *Automotive Transmissions and Power Trains*, 5th ed., by William H. Crouse and Donald L. Anglin, 1976.

a. Low oil level
b. Roller clutch damaged
c. Detent switch sticking or defective
d. Manual linkage maladjusted

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NOTE: For items 16 through 20 you will need access to a professional service manual, such as Chilton's, Motor, or Mitchell, that includes service procedures for 1985 vehicles or service manuals for each vehicle in the following problems.

16. What is the torque required for the lower mounting bolt for the rear shock absorbers on a 1985 Omni?

    a. 30 foot-pounds
    b. 40 foot-pounds
    c. 45 food-pounds
    d. 47 foot-pounds

17. Which of the following is the correct firing order for a 1985 305 cubic inch Chevrolet engine?

    a. 1-6-2-4-8-5-7-3
    b. 1-8-3-4-6-7-5-2
    c. 1-8-4-3-6-5-7-2
    d. 1-6-2-8-5-4-7-3

18. According to the wheel alignment specifications for a 1985 Mercury Topaz, what is the steering axis inclination in degrees for the left front wheel?

    a. 14 5/8
    b. 15 1/8
    c. 15 5/8
    d. 16 1/8

19. Technician A says that on a 1985 American Motors Corporation vehicle with a 258 cubic inch engine, the idle mixture is adjustable. Technician B says the idle speed for this engine with an automatic transmission (transmission in drive) is 700 rpm.

    Who is right?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

20. The spark plug gap on a 1985 Fiero is

    a. .060 inch
    b. .045 inch
    c. .035 inch
    d. .028 inch

NOTE: For items 21 through 23, refer to the chart below to interpret vehicle identification number information. For these questions, use the following Chrysler Corporation VIN:

1B3BA44D0GG19019

1986 VIN CODE CHART

(FRONT WHEEL DRIVE VEHICLES)

POSITION	CODE OPTIONS			INTERPRETATION
1	1 = U.S. 2 = Canada	3 = Mexico J = Japan		Country of Origin
2	B = Dodge C = Chrysler	P = Plymouth		Make
3	3 = Passenger Car 7 = Truck			Type of Vehicle
4	B = Manual Seat Belts D = 1-3000 Lbs. GVW			Passenger Safety System
5	C = LeBaron D = Aries E = 600 T = New Yorker X = Lancer	L = Caravelle (Canada) M = Horizon P = Reliant J = Caravelle (U.S.)	V = 600 Z = Omni A = V Daytona A = C Laser H = LeBaron GTS	Line
6	1 = Economy 2 = Low	4 = High 5 = Premium	6 = Special	Series
7	1 = 2 Dr. Sedan 2 = 2 Dr. Specialty Hardtop 3 = 2 Dr. Hardtop 4 = 2 Dr. Hatchback	5 = 2 Dr. Convertible 6 = 4 Dr. Sedan 8 = 4 Dr. Hatchback 9 = 4 Dr. Wagon		Body Style
8	A = 1.6L C = 2.2L	D = 2.2L EFI E = 2.2L Turbo	K = 2.5L	Engine
9*	(1 thru 9, 0 or X)			Check Digit
10	G = 1986			Model Year
11	A = Outer Drive C = Jefferson D = Belvidere F = Newark G = St. Louis 1	K = Pillette Rd. N = Sterling R = Windsor	T = Toluca X = St. Louis 2	Assembly Plant
2 thru 17	(6 Digits)			Sequence Number

*Digit in position 9 is used for VIN vertification

Used with permission of Chrysler Corporation.

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21. This VIN belongs to a

    a. Chrysler New Yorker
    b. Dodge Aries
    c. Dodge Lancer
    d. Dodge Daytona

22. The engine in this vehicle is a

    a. 2.2 liter EFI
    b. 2.2 liter turbocharged
    c. 2.2 liter
    d. 2.5 liter

23. The body style of this vehicle is

    a. 2-door sedan
    b. 2-door hardtop
    c. 2-door hatchback
    d. 2-door convertible

24. The two most common types of electrical circuit protection devices are the cartridge fuse and the

    a. Spring-loaded circuit breaker
    b. Bimetal circuit breaker
    c. Fusible link
    d. Blade-type fuse

25. Fuses are generally rated in

    a. Amperes
    b. Watts
    c. Volts
    d. None of the above

26. Technician A says that a wiper blade assembly can be checked for proper tension by raising the assembly about four inches from the glass and releasing it to see if it snaps back. Technician B says that the life of a wiper blade may be extended by removing the blade, reversing ends, and reinstalling it at approximately 12,000-mile intervals.

    Who is right?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

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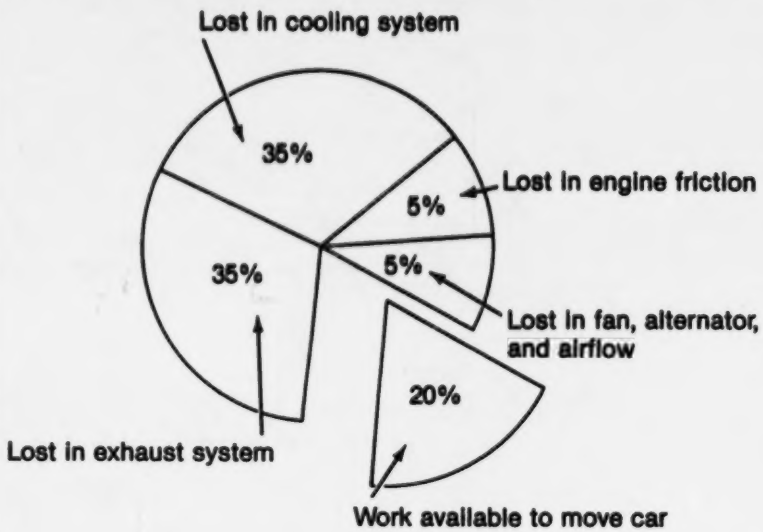
27. The best definition for *model of vehicle* is

a. The brand name of the vehicle
b. Manufacturer's designation of year for a vehicle
c. The option package of the vehicle
d. The body style of the vehicle

28. Which of the following types of reference materials may contain suggested retail price of parts?

a. Shop manual
b. Service bulletin
c. Parts guide
d. Both b and c

29. According to the circle graph below, what percentage of combustion energy is lost to internal engine friction?



Used with permission of Ford Motor Company.

a. 15%
b. 10%
c. 5%
d. 4%

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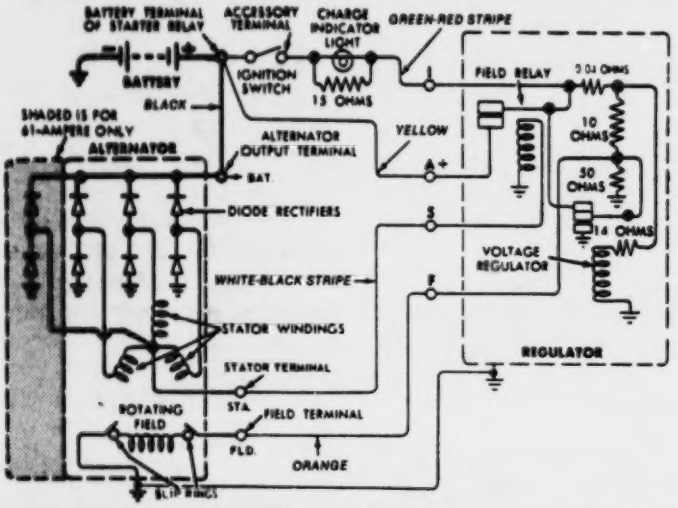
30. In the schematic diagram below, the wire between the battery terminal of the starter relay and the alternator output terminal is what color?



Charging system schematic with electro-mechanical regulator and charging light

Used with permission of Ford Motor Company.

a. Yellow
b. Orange
c. Black
d. White-black stripe

NOTE: For items 31 through 33, you will have to apply sound troubleshooting principles. More than one choice may be correct for each item, but you should mark the choice that makes the *most* sense for efficient, systematic troubleshooting. Be sure to read the notes following each set of answers.

31. A customer calls your shop and tells you that his vehicle will not start. When you arrive at the customer's house and try to start the vehicle, you find that nothing happens when you turn the key. Which of the following is the *most likely* cause of this problem?

a. A lack of fuel to the carburetor, such as the vehicle being out of fuel, having a clogged fuel line, or having an inoperative fuel pump
b. A lack of spark in the combustion chamber, such as might occur with a faulty ignition coil or improper ignition timing
c. A mechanical failure in the starting system, such as missing teeth on the flywheel or an improperly installed starter
d. An incomplete circuit in the starter electrical system, such as a dead battery, a defective neutral safety switch, or a loose connection

NOTE: If you marked either A or B for item 31, go to item 32-A. If you marked either C or D for item 31, go to item 32-B.

32-A. In order to determine whether the failure to start is due to a fuel problem or an ignition problem, which of the following is a best next step?

a. Disconnect the fuel line that goes into the carburetor, crank the engine, and check for fuel
b. Disconnect the fuel line at the inlet side of the fuel filter, crank the engine, and check for fuel
c. Disconnect the primary wire at the coil, hold a screwdriver between the coil terminal and a good ground, crank the engine, and check for spark
d. Disconnect a spark plug wire from a spark plug, hold a screwdriver between the end of the wire and a good ground, crank the engine, and check for spark

NOTE: Write your answer in the space numbered 32 on your answer sheet. If you answered either A or B, go to item 33-A. If you answered either C or D, go to item 33-B.

32-B. In order to determine whether the failure to start is due to a mechanical or electrical problem in the starting system, what should you do first?

a. Turn on the headlights, check to see that they are on, and note what happens to the headlights
b. Replace the battery or connect another battery to the vehicle with jumper cables and then see if the vehicle will start
c. Remove the starter and conduct a series of electrical tests on the starter
d. Check to make sure that the vehicle is set to start, such as being in the correct transmission position and having the driver's seat belt fastened if required

NOTE: Write your answer in the space numbered 32 on your answer sheet. If you answered either A or B, go to item 33-C. If you answered either C or D, go to item 33-D.

33-A. When you try to start the vehicle after disconnecting the fuel hose, the engine still does not crank. No fuel comes from the hose. What do you do next?

a. Decide that the problem is not a fuel problem, that it is probably an electrical problem
b. Decide that the problem is not a fuel problem, that it is probably an ignition problem
c. Replace the fuel filter
d. Replace the fuel pump

33-B. When you try to start the vehicle to check for spark, the engine still does not crank. There is no spark. What do you do next?

a. Decide that the problem is not an ignition problem, that it is probably an electrical problem
b. Decide that the problem is not an ignition problem, that it is probably a fuel problem
c. Replace the coil
d. Replace the spark plugs

33-C. When you try to start the vehicle (either with the headlights on or with a different battery), the engine still does not crank. There is no indication that power is being drawn from the battery, such as dimming of the headlights if they are on or a change of engine speed if the emergency jump procedures are being used. What do you do next?

a. Decide that the battery is okay and check for some other problem in the starter electrical system
b. Decide that the starter electrical system is okay and check for a problem in the starter itself
c. Decide that the starting system is okay and check for a problem in the fuel system
d. Decide that the starting system is okay and check for a problem in the ignition system

33-D. If your check in the previous step indicated no problems, what would you do next?

a. Check the wiring and electrical connections in the starter electrical system
b. Test the starter relay or solenoid
c. Decide that the starting system is okay and check for a problem in the fuel system
d. Decide that the starting system is okay and check for a problem in the ignition system

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INFORMATION SHEET

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 1

Recognize definitions of terms associated with automotive service reference materials

Reference materials — Books, pamphlets, charts, and other materials used by automotive service technicians as sources of information in servicing vehicles

Illustrations — Drawings, photographs, diagrams, and other graphics used to clarify information contained in reference materials

Specifications — Measurements and features that apply to a specific make and model of vehicle as that vehicle is equipped

EXAMPLES: Measurements — Fluid quantities, clearances, torques, pressure values

Features — Type of fuel system, engine design, transmission design

Make of vehicle — Identification of a vehicle according to its manufacturer, name, and special designations

EXAMPLES: Ford Escort GT, Oldsmobile Cutlass Supreme, Dodge Lancer ES

Model of vehicle — Manufacturer's designation of year for a vehicle

NOTE: The model year is not exactly the same as the calendar year since most manufacturers release their new models in September. Thus, 1987 models appeared in dealerships in September of 1986. Sometimes a new make of car will come out in the spring, and the manufacturer will refer to it as a half-year model. The Mustang, for example, was introduced by Ford as a 1964 ½.

Family of vehicles — Makes of vehicles related to each other because of design similarities

NOTE: Because manufacturers produce similar vehicles under different company names, the phrase *family of vehicles* is a rather broad one. For example, the Ford Taurus and the Mercury Sable are of pretty much the same design with very similar options and for that reason can be grouped together as a family. However, the term is also applied to the vehicles of one manufacturer or those of one manufacturing division, so that all Buicks could be called a family or all Toyotas could be called a family.

Option — Vehicle feature other than those included in basic design package; usually available at additional cost

EXAMPLES: Engine size, interior materials, power accessories

Domestic vehicle — One that is primarily manufactured and assembled in a person's home country

Imported vehicle — One that is primarily manufactured and assembled in a country other than a person's home country

NOTE: The distinction between domestic and imported vehicles has lessened in many ways over the past few years. Many U.S. manufacturers import vehicles and sell them with domestic names, such Dodge Colt and Mercury Merkur. Some U.S. manufacturers have assembly plants in Canada, Mexico, or other countries, while some foreign manufacturers such as Volkswagen and Honda have plants in the United States. And finally, some U.S. companies and foreign companies have joined forces to produce such cars as the Chevrolet Sprint and Chevrolet Nova.

OBJECTIVE 2

Determine reference materials that can be used as the source for specific information

Service manual (shop manual) — Book or books developed by a vehicle manufacturer for a model or family of vehicles, giving information about the design and operation of and describing service procedures for that model or family of vehicles

Owner's manual — Booklet developed by a vehicle manufacturer for a particular make and model of vehicle; designed to provide the user with general care and maintenance instructions and specifications

Professional manual — Book or books developed by agencies other than vehicle manufacturers that give information and describe service procedures for a wide range of makes and models of vehicles

EXAMPLES: *Chilton's Auto Repair Manual, Mitchell Manuals' Imported Car and Light Truck Mechanical Manual, Motor Truck and Diesel Repair Manual*

NOTE: Professional manuals generally cover procedures required for vehicles manufactured during a period of several years and are usually published with separate volumes for domestic cars, domestic trucks, and imported vehicles.

Service bulletin — Short document developed by a vehicle, equipment and tool, or parts manufacturer or by a professional manual publisher to update information or procedures

NOTE: Service, owner, and professional manuals are generally published once per year while bulletins are printed as the need arises, often as supplements to other publications.

One step more . . .

Why So Many Books?

Hudson, DeSoto, Packard, Studebaker, Cord. How many of those have you heard of? They are all makes of cars that at one time were manufactured in the United States, and this list is far from complete in naming all the manufacturers that have produced cars during the past 90 years. So, what does a service technician do if someone needs a tune-up on a 1957 DeSoto or a brake job done on a 1963 Studebaker Lark? A quick check of a service manual will show you that even for a single manufacturer today, the variations for a vehicle are great. For 1986, Chrysler front-wheel-drive passenger cars were produced as 3 different makes, 14 lines, 5 series, 8 body styles, 5 engine options, 3 transaxle options, 5 types of fuel systems, and many other variations that affect specific service procedures. Multiply this number of variations by the number of domestic and import manufacturers, and you will see why there are so many different manuals. The publishers of these books try to organize their material in order to help users. For example, Section 6 of GMC manuals deals with engines; Chilton manuals consist of C (car) sections and U (unit) sections. Look over the manuals you have in your shop. What do they cover, and how are they organized? Could you find the information needed to service a 1963 Studebaker Lark?

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Specialty manual — Book developed by any of various agencies to cover a limited topic, such as one system of a vehicle, one aspect of design or operation, a single approach to service, etc.

EXAMPLES: *Mitchell Emission Control Service and Repair: Domestic Cars, GM Advanced Electronic Fuel Injection, NAPA Belt Clinic Manual, Ford 1978-1985 Electronic Engine Control Systems*

Flat-rate manual — Guide to approximate reasonable time requirements for repair and maintenance procedures for various vehicles; used to estimate and determine labor charges

Parts guide — Collection of drawings that show vehicle parts and listings that give manufacturers' parts numbers; may contain other information such as the suggested retail price of parts

NOTE: Flat-rate and parts information are sometimes combined in one publication.

Interchange manual — Guide that lists numbers of parts by other manufacturers that may be substituted for the vehicle manufacturer's original equipment

EXAMPLES: Interchangeable Mopar parts for comparable Dodge and Plymouth models, replacement equipment such as oil filters and spark plugs by various manufacturers

High-Tech Service Manuals

The automotive service technician must have a lot of information available, especially if the technician is to provide service for a wide range of makes and models. Are today's service technicians taking advantage of the latest developments in information storage and retrieval? For a number of years now, parts suppliers and others have offered *microfiche* copies of parts guides. Microfiche are small plastic cards containing very small photographs of several pages from a book or books. This allows storage of several thousand pages of information in a very small space. By using a special viewer, a person can read the magnified pages. With the increased use of personal computers, there is the possibility that automotive service information will soon be stored electronically and called up as needed. Some vehicles have onboard computers that store operation and design specifications and compare them to vehicle performance, often providing the service technician with a diagnosis of the problem and sometimes guides for repair. Computer software is being developed to refine this process further and for use in training technicians. The increased use of laser discs will also affect the way we store and retrieve information, meaning new aids for technicians and new skills to learn.

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

SUPPLEMENT 1

Organization of Reference Materials

The various reference materials that an automotive service specialist uses come in many different designs. However, each design generally has its own logical system. This system makes the material easier to use. The service specialist must become familiar with these reference material designs in order to make the most of the information available.

Reference materials usually have a *table of contents*. The table of contents lists the subjects covered in the book and tells on what page that subject begins. Automotive service references are often divided into sections—sometimes with one subject covered in each section. For example, vehicle manufacturers frequently divide their service manuals according to vehicle systems. Fuel systems may be Section 5, while steering systems may be Section 7. Usually all the books by that manufacturer will have the same section number for the same system year after year. This helps the service specialist who is familiar with the book to find information more easily. Check the tables of contents for two service manuals from the same vehicle manufacturer for different model years. Compare the numbering of the sections. Are they the same? Notice also how pages and illustrations are numbered.

Now check the tables of contents for service manuals from different vehicle manufacturers. Show how service materials are organized by writing in the chart the section number for each topic in service manuals for the vehicle manufacturers listed.

Topic	General Motors	Ford	Chrysler
Brakes			
Steering			
Chassis Electrical			
Manual Transmission			
Towing			

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Other types of resource materials also use systematic organization. Professional manuals, for example, often have one part that deals with systems in a general way and another that deals with specific makes and models of vehicles. Check some of the professional service manuals in your shop, such as Chilton's, Mitchell's, and Motor. Chilton's manuals, for example, are divided into two parts—one consisting of sections for various cars and one consisting of sections on unit repairs. Part 1 is subdivided into numbered sections for various families of cars and the page numbers are coded with a "C" (for *car sections*). The unit repair sections are page numbered with a "U." How are other professional manuals divided? Compare the various types in your shop.

Check a number of other types of service reference materials. Do they also have sections and other divisions? For example, check a collection of service bulletins. How are they divided in terms of dates, systems, and vehicle manufacturers?

As you continue your studies and go into your career, you will use many different types of reference materials and will become familiar with how they are organized. A little study now will help you to master these skills faster. A lot of people overlook the introductions and prefaces to these books. But, if you read them, you may find that you have a head start on the pack.

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USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

SUPPLEMENT 2

Interpreting Illustrations

You have probably heard the expression "A picture is worth a thousand words." There is some truth to this saying because it is often easier to show through pictures what would be difficult to explain in words. For this reason, service manuals and other automotive references frequently use illustrations to show assemblies or clarify procedures that would be hard to describe clearly with just words.

The two most common types of illustrations in automotive reference materials are photographs and drawings. Illustrators refer to the way they represent objects in drawings as ***rendering***. The amount of detail, the use of realistic light and shadow representations, the thickness of lines, and many other aspects of the drawing vary, depending on the purpose of the illustration. For example, a ***presentation illustration***—one intended to make a place or product look appealing—may show many details and be done in color, while a drawing used to illustrate the parts of an assembly may be a simple ***line drawing***. In most cases, automotive reference materials use simple drawings that show only enough detail to make clear what is being represented.

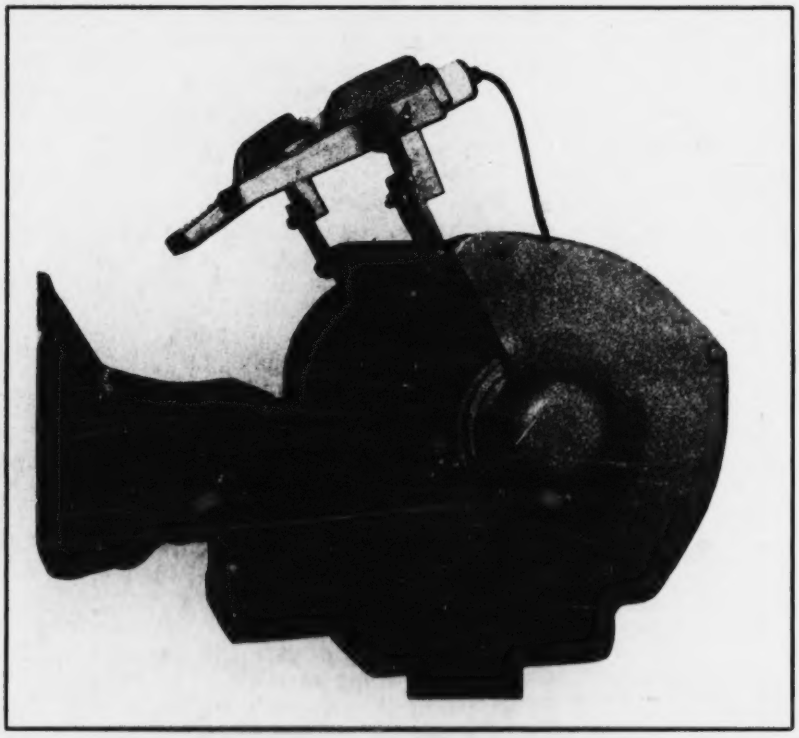
The Alphabet of Lines

Technical illustrators use a variety of lines in their drawings to represent different aspects of what is referred to as the *alphabet of lines*. Some of the more important lines used in automotive service reference materials are shown below.

- Object line shows edges of object
- Hidden line shows edges of object that cannot be seen by viewer
- Center line shows middle of object or center of circle or hole
- Section line shows how object has been "cut away" for sectional view
- Break lines show that part of an object has been omitted
- Flow line shows how parts in an exploded view fit together
- Phantom line shows edges of object in a phantom view drawing

However, even simple drawings can be difficult to understand, unless one knows how to "read" them. There are many reasons for this difficulty. One of the most important is that drawings try to show objects of various sizes and shapes on a flat surface, usually at less than full size. Often, too, objects in drawings look very different than they do as the service specialist is likely to find them. In drawings, details and surrounding objects may be left out to keep the drawing simple, even though such references may be useful in helping the service specialist identify the parts shown in the drawing.

Photographs are also used for automotive service reference illustrations. Photographs are sometimes altered to more clearly show the important part of the illustration. Common methods of altering photographs include cutting away background areas, covering such areas with a ***screen***, and highlighting certain portions of the photograph to make them clearer. The photograph below shows the use of screening.



Whether an illustration is a drawing, a photograph, or a combination of both, it is likely to fall into one of several types of illustrations commonly used in technical publications. Several different techniques are used to show the relationships among parts of an assembly or components of a system.

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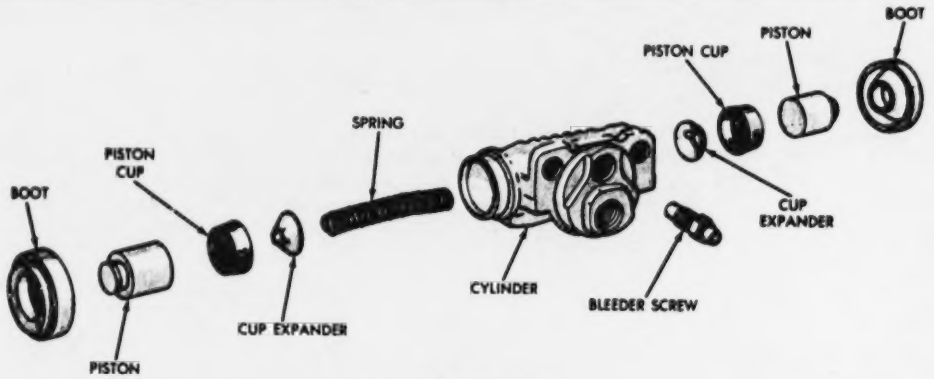
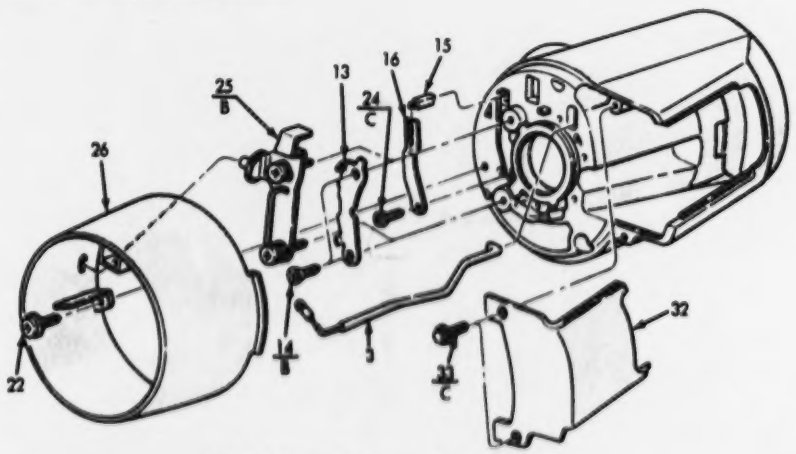
Reference materials often contain ***exploded views***. An exploded view shows the parts of a component spaced out from their assembled positions. This technique is useful for identifying the parts of a component and for showing how those parts fit together. The relationship of the parts may be shown by just the position of the parts as in the first illustration or through the use of ***flow lines*** as shown in the second illustration.



(a) Exploded view

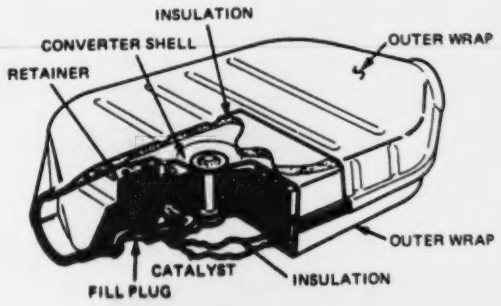
Used with permission of Chrysler Corporation.



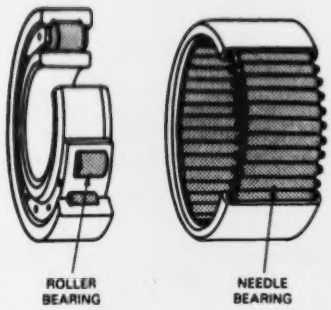
(b) Exploded view with flow lines

Adapted with permission of Chrysler Corporation.

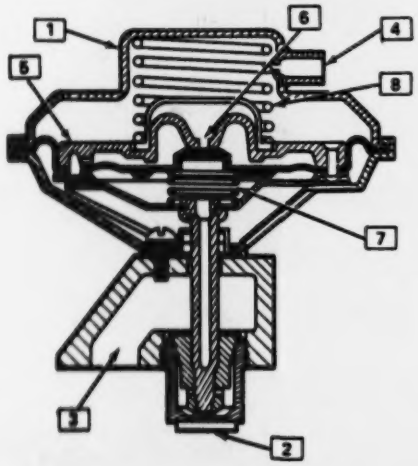
Another method for showing the parts of a component is the use of ***cross-sectional views***. In a cross-sectional view, the component is shown as if part of it had been removed. This technique is helpful because it reveals individual parts—especially internal ones—in their assembled positions.



(a) Broken representation



(b) Cutaway representation



(c) Cutaway with mechanical drawing representation

There are three common methods for representing cross-sectional views. Illustration (a) on the left is called a ***broken representation***. It shows a catalytic converter as if part of it had been broken off to reveal the insulation, converter shell, catalyst, and other internal features. Illustration (b) is a ***cutaway representation***. Like the broken representation, the cutaway shows the component as if part of it had been removed. However, in the cutaway representation, the removed portion appears to have been cut instead of broken. The final type of cross-sectional representation shown is the ***mechanical-drawing*** type. It shows the part as if one straight-line cut had been made through the component. To distinguish among separate parts, diagonal lines of different thicknesses, angles, and spacing are used. Other symbols may also be used, such as the way the threads are shown on the screw near the middle of the drawing and the way the spring (labeled "8") is drawn. In some cross-sectional views, a spring may be represented as two rows of circles, indicating just the cut ends of the coils.

(a) Used with permission of General Motors Corporation, Pontiac Motor Division.

(b) Reproduced by permission of Deere & Company. All rights reserved.

(c) Used with permission of General Motors Corporation, Chevrolet Motor Division.

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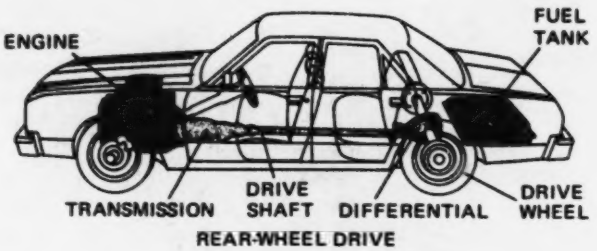
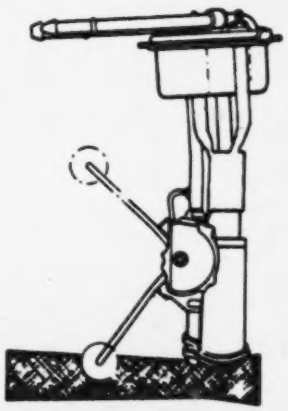
Another technique for showing the internal parts of an assembly or components of a system is the ***X-ray view***. In an X-ray view, parts are shown as if the viewer could see through the outside parts. Generally, only selected internal parts are shown, as in the drawing below.



X-ray view

Reprinted with permission of McGraw-Hill Book Company, Gregg Division, from *Automotive Body Repair and Refinishing*, by William H. Crouse and Donald L. Anglin, 1986.



Phantom-position drawing

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

In an X-ray view, all parts may be drawn in a similar style or the outer parts may be drawn differently to emphasize the internal parts. Outer parts may be drawn with less detail, with lighter lines, or with special lines called ***phantom lines***. In some cases, the internal parts are drawn using phantom lines. Another use of phantom lines is shown on the left. This is called a ***phantom-position drawing***. Phantom-position drawings are used to show a movable part in a second position. In the example shown, the rod with a ball on the end of it is a float that moves up or down with changes in the fuel level. The float is shown in its lowest and highest positions. Phantom lines have been used to show the float in the upper position.

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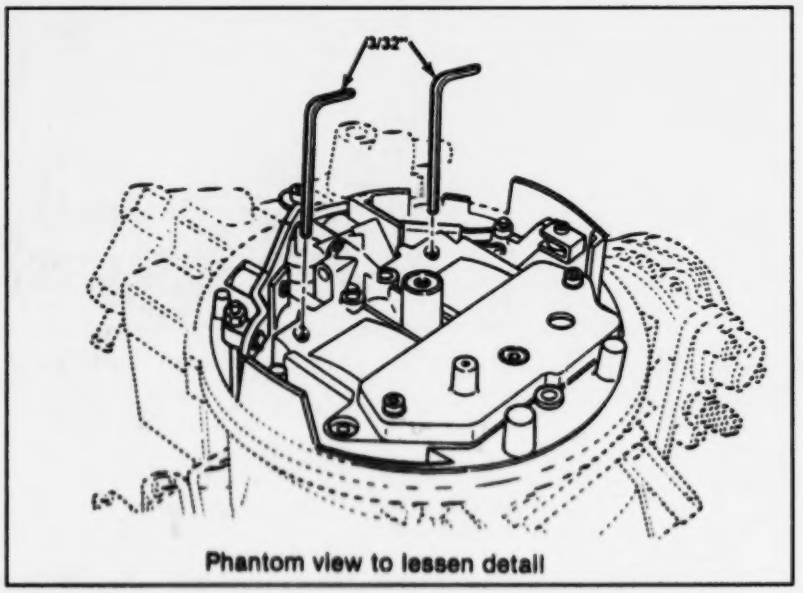
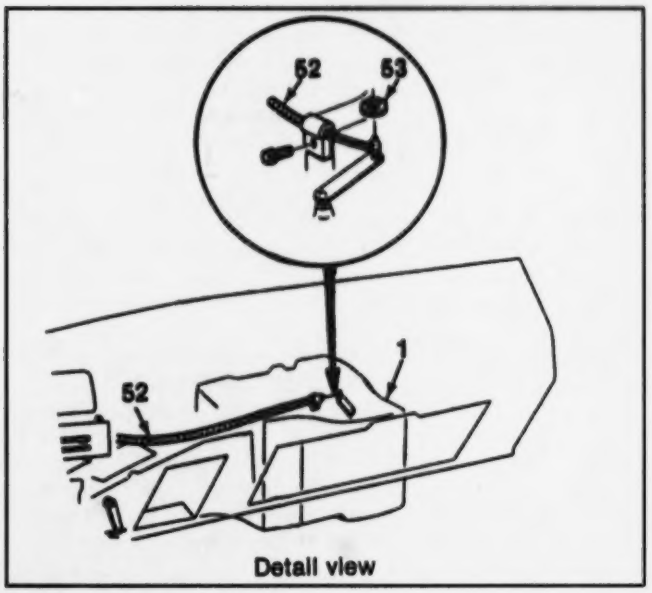
Yet another type of phantom view is shown in the drawing below. In this type of drawing, some features are emphasized through the use of normal object lines, while parts less important to the purpose of the drawing are shown in phantom lines.



Phantom view to lessen detail

Used with permission of Ford Motor Company.



Detail view

Adapted with permission of General Motors Corporation, Chevrolet Motor Division.

Another way of emphasizing selected details on an illustration is to include a second, smaller drawing on the illustration. Such drawings are normally enclosed in circles with an arrow or some other method used to indicate how the smaller drawing relates to the first. The two most common uses of this technique in automotive reference materials are shown at the left. The upper drawing uses a ***detail view*** to show one portion of the drawing more clearly. Illustrators draw objects at a certain proportion of their actual size, such as one-tenth. This proportion is called ***scale***. Thus, in a one-tenth scale drawing, a rod 10 inches long would be shown 1 inch long. Detail views are usually drawn at a different scale, one closer to actual size so that more details are shown.

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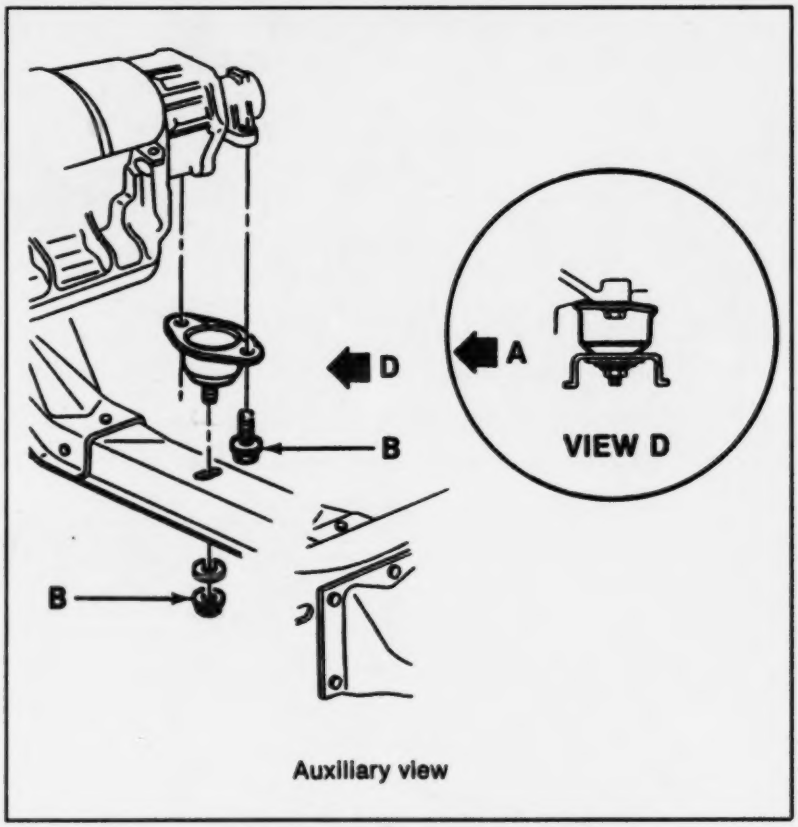
The drawing below is called an ***auxiliary view***. Auxiliary views show a portion of the primary drawing from a different angle or viewpoint, but usually at the same scale. Through the use of auxiliary views, important features not apparent in the primary drawing can be shown without doing a completely new illustration.



Auxiliary view

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The information you have studied in this supplement should enable you to interpret most of the illustrations you are likely to encounter in automotive service reference materials.

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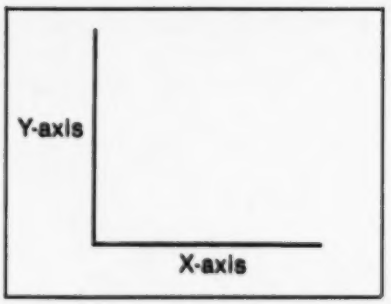
SUPPLEMENT 3

Interpreting Graphs

Graphs are a special kind of drawing generally used to show how two or more things change in relation to each other. Such changes are important for the automotive service specialist to understand because vehicle operation involves so many changing quantities. For example, one changing quantity of which you are aware is engine speed—by moving the accelerator pedal you can increase or decrease the speed at which engine parts move. Changes in engine speed influence how quickly fuel is used, how quickly the engine heats up, vehicle speed, stopping distance, and other characteristics. Graphs are convenient ways of showing how such changes relate to each other. The quantities that change are called ***variables***.

The most commonly used graph design for showing changing variables is called the ***axis graph***. An axis is a line used to show measurement of a variable. The plural of axis is axes (aks-eez), and an axis graph will usually have two axes as shown below. The vertical (up and down) axis is referred to as the ***y-axis***, while the horizontal (across) axis is called the ***x-axis***.



A variable is shown on each axis, and the axes are marked off in ***units of measurement***. Sometimes the point where the two axes meet represents zero, but it may be almost any point in the measurement of the variables. Some graphs use lines called ***grids*** that extend across the graph parallel to each axis. Grid lines mark the units of measurement on the graph.

The last major part of a graph is called the ***plot line***. The plot line shows how the variables relate to each other at any point along either axis. Let's create a graph to see how this works. We will make a graph to show how the mileage on a vehicle increases as time passes. Joan Barker bought a new car, on August 10. For the first six months that she owned the car she checked the mileage on the tenth of each month. This is what she found: August 10, 4 miles; September 10, 672 miles; October 10, 1190 miles; November 10, 1859 miles; December 10, 2437 miles; January 10, 3844 miles; and February 10, 4387 miles.

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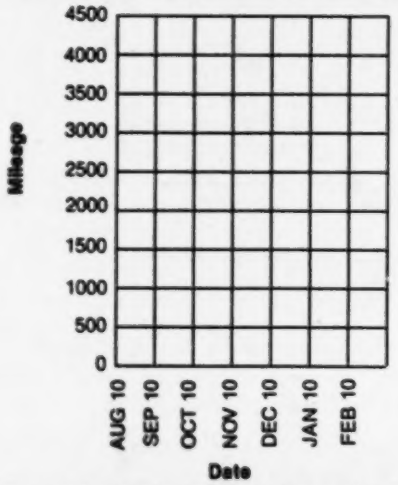
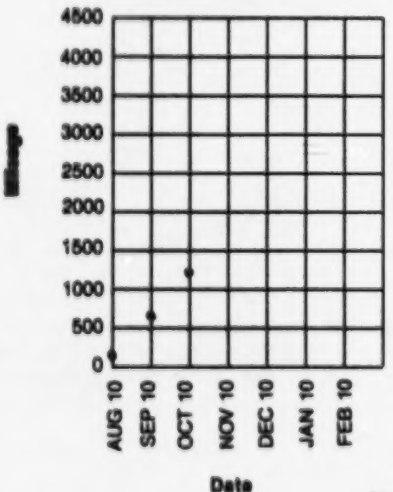
First we have to identify the variables. The two things that change in this example are the date and the mileage on the vehicle. The units of measurement are defined by the variables: one axis will simply show the dates while the other will show total miles driven as of each date. We have lots of choices, but for our example, let's use the x-axis for dates and the y-axis for mileage with one vertical grid line for each date and a horizontal grid line for each 500 miles. If we mark grids up to 4500 miles, our graph would look like this:



The next step is to mark the points that show the relationship between the dates and the total mileage. On the first day Joan had 4 miles on her car, which is close to zero on our scale. A month later, she had driven a total of 672 miles, so we mark a point approximately one-third of the way between the 500-mile and 1000-mile grids (672 – 500 = 172; 172 ÷ 500 = .344). The mark for Joan's October 10 mileage would be a little more than one-third of the way between the 1000-mile and 1500-mile grids. The graph below shows these first three points marked.



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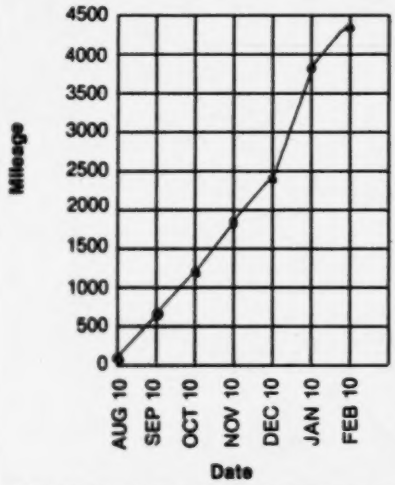
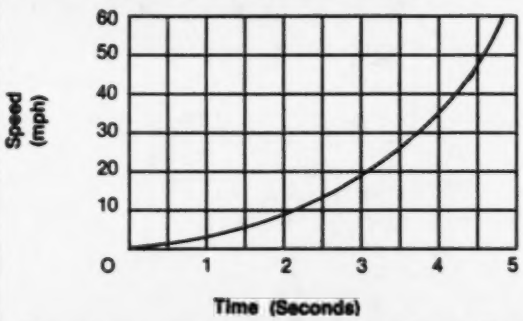
If we continue to mark the monthly points and then connect them with lines, we produce a graph like the one below.



Now, that we have this graph, what can we tell from it? For one thing, we can compare the total set of figures all at once better than we could when we just had a list of numbers and dates. The list gives us more exact information, but the graph does a better job of showing us how much Joan has driven each month. We can see, for example, that between December 10 and January 10 Joan drove more than twice as far as she did in most other months.

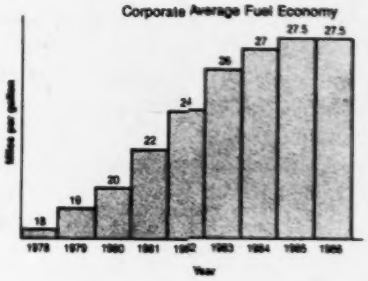
The type of graph we have just created is called a ***mathematical graph***. A mathematical graph shows the value of a variable at specific points—in the case of our example, on the tenth of each month. Of course, the mileage on Joan's car did not increase at a steady rate from the tenth of one month to the tenth of the next. On some days she may have driven more than 100 miles while on others she may not have driven the car at all. Sometimes it is important to be able to tell the change in a variable or the relationship between variables at many different points. To do this, the plotted information must be based on much more data than what we used in our example above. This type of graph is called a ***plane-curve*** graph. Below is a plane-curve graph showing the 0-mph to 60-mph acceleration of a vehicle.



Plane-curve graphs are read just like mathematical graphs but have the advantage of being able to show the relationship between the variables at any point. For example, if we want to know how fast the car was going after 3.5 seconds, we can find that point on the curve. The answer is approximately 27 mph. Also, if we want to know how long it took the car to reach 45 mph, we can see from the graph that it took approximately 4.4 seconds.

This type of graph also allows us to make comparisons between various portions of the graph. For example, we can compare the rate of accelerations for various time segments. The vehicle went from approximately 3 mph to 10 mph between the first and second seconds, an acceleration speed of 7 mph per second. Between the second and third seconds, the vehicle's speed increased from 10 mph to 20 mph, which equals an acceleration rate of 10 mph per second. What was the acceleration rate between the third and fourth seconds? Between 3.5 and 4.5 seconds?

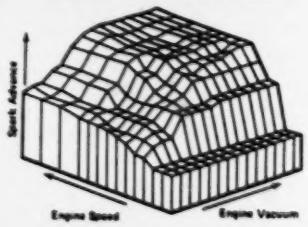
A type of graph similar to the mathematical graph is the ***bar graph***. Bar graphs use extended boxes to represent quantities. In the graph below, the average fuel economy for American-made vehicles is depicted through the use of bars. The graph below shows that the corporate average fuel economy increased from 19 miles per gallon in 1979 to 27.5 miles per gallon in 1985.



Graph designers often use drawings in place of bars to show the variables on a bar graph. For example, gasoline pumps could have been used for the fuel-economy graph. The graph is read the same way, even though drawings are used instead of bars. Note also that you must be careful that you understand what is being shown in bar graphs and other graphs.

Three-Dimensional Graphs

Sometimes it is necessary to show more than two variables on a graph. Usually this can be done with a plane-curve graph using two curves. For example, we could use the graph on the previous page to compare the acceleration of two or more vehicles simply by adding other curves to show the 0-to-60 rates for other vehicles. Occasionally, however, a graph will be used to show the relationship of three variables at the same time. This is done by adding a third axis (z-axis) and producing what is known as a ***three-dimensional graph***. The three-dimensional graph below shows the relationship among engine speed, spark advance, and engine vacuum. It shows that as engine speed increases there is no effect on engine vacuum or spark advance, at first. However, as engine speed continues to increase, both spark advance and engine vacuum build.



Spark advance map

Used with permission of General Motors Corporation, Buick Motor Division.

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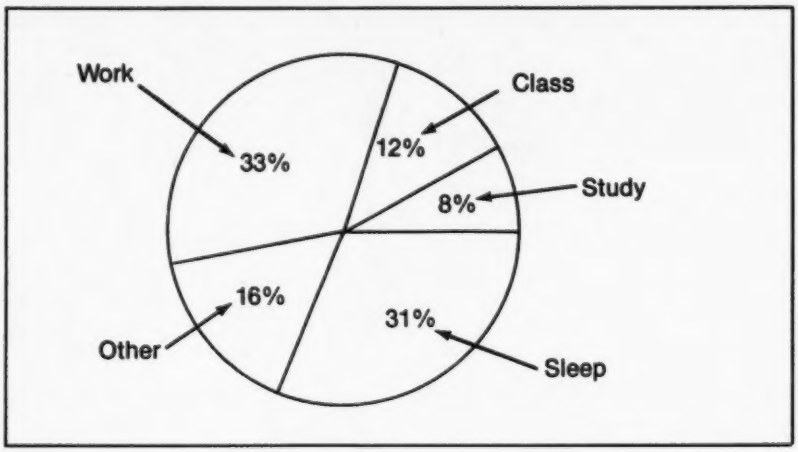
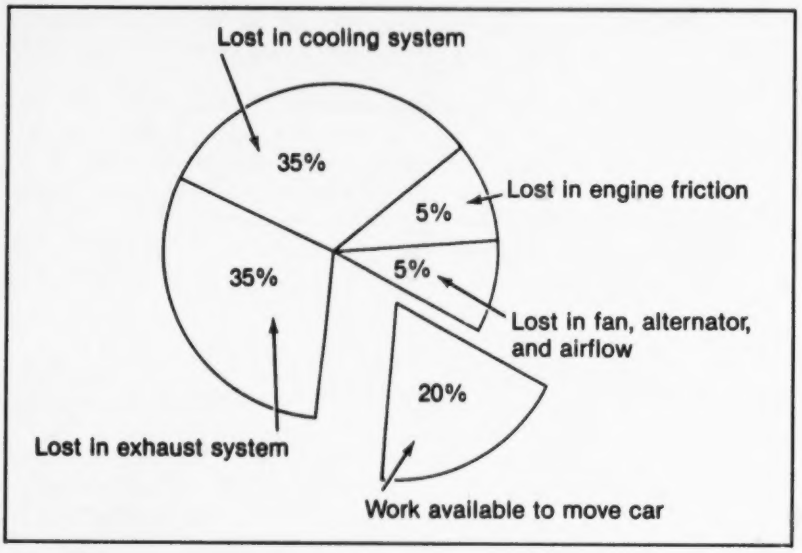
The fuel-economy graph on the previous page is useful primarily to show the fuel-economy level and that it increased each year during the period shown. However, there is no scale on the y-axis, so we don't know where the graph starts in showing fuel economy. We can estimate the scale to start at approximately 17 mpg based on the bars. The important thing to remember is that not all of each bar is shown—probably to save space. Thus, although the bar for 1981 is twice as tall as the bar for 1980, this does not mean that fuel economy doubled in that 12-month period.

Another graph that frequently appears in automotive service reference materials is the ***circle graph*** or ***pie chart*** as it is often called. Circle graphs are used to show how a whole quantity is made up of various parts. These parts are generally shown as percentages of the whole. The circle then represents 100 percent of the quantity, and each percentage part can be shown as a slice of the pie. Let's make a circle graph of how one automotive service worker spends a typical day. John Whitehorse works at his job 8 hours on most days. He spends 3 hours each evening in class studying to become an engine performance specialist. After class, John and some of this classmates get together for approximately 2 hours to relax and to study. Afterwards, John goes home and sleeps an average of 7 hours per night. The other 4 hours of John's day are spent eating, going to and from his various activities, changing clothes, and taking care of the other details of daily living. A circle graph for a typical day in John's life is shown below. You can see why he looks forward to the weekend so much.



Circle graphs are fairly simple to read because the variables and their percentages are generally written out. They are helpful, though, in relating the proportions among several aspects of a total quantity. For example, the circle graph below illustrates the total energy output from the combustion of gasoline in an engine and how that energy is used or lost.



Used with permission of Ford Motor Company.

Shaded areas cover regions where minimum temperatures may be consistently below −12°C (+10°F) during some winter months

Used with permission of Chrysler Corporation.

The final type of graph commonly used in automotive service reference materials is the ***pictorial graph***. The pictorial graph uses an illustration, part of which is made distinct from the rest of the illustration, to convey information. In the pictorial graph at left, a portion of North America is shaded with lines. The shaded area represents regions where winter temperatures are consistently below −12°C (10°F).

All the graphs you have studied are used in automotive service reference materials to convey information. By knowing how to interpret such graphs, you will be more skilled as an automotive service specialist.

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USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

SUPPLEMENT 4

Interpreting Diagrams

A diagram can be thought of as a map. Diagrams show how something gets from one point to another. That "something" can be just about anything that moves through space or time. For example, a diagram may show how fuel gets from the fuel tank to the engine. Such a diagram maps the movement of a substance. Another diagram may trace the flow of power from the brake pedal to the contact between the brake disc and rotor. This diagram would show the movement of energy through a system. Diagrams are also used to map the actions a service specialist has to follow in completing a procedure, especially when the specialist faces different choices for various responses.

The points on a diagram are connected by lines. One key to understanding diagrams is knowledge of what the lines mean. A simple straight line may connect two points, or a line with an arrowhead may be used to indicate flow in a certain direction. Lines may be coded with colors or symbols to indicate specific paths. Information connected by lines may be presented as words, symbols, or drawings.

There are four general types of diagrams used in automotive service reference materials. Three of these are used primarily to show the flow of a substance or energy through a system while the fourth type of diagram is most often used to outline service procedures or some other sequence of events or operations. Those that show the flow of a substance or energy will be addressed first.

All three diagrams in this category are quite similar. The major difference among them is the method used to represent parts, components, and other elements in the system. In a ***block diagram***, boxes with the component name represent elements in a system. In the example on the following page, the parts of an electronically controlled fuel-injection system are shown. Note that in this example, both the flow of energy and the flow of a substance are shown. Fuel flows through one circuit, while electrical signals flow from the electronic control module to the fuel injectors. Arrows show the directions of flow.

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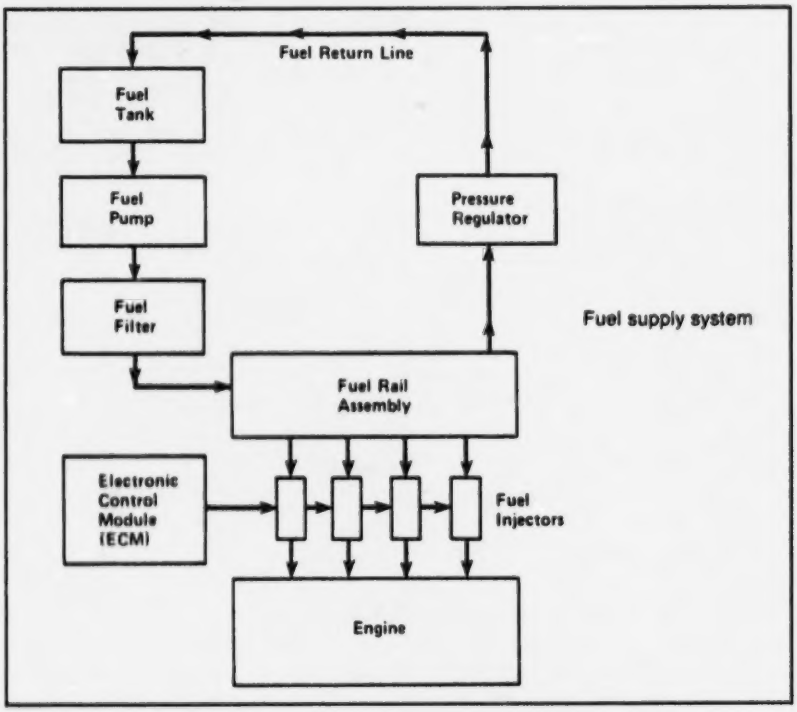
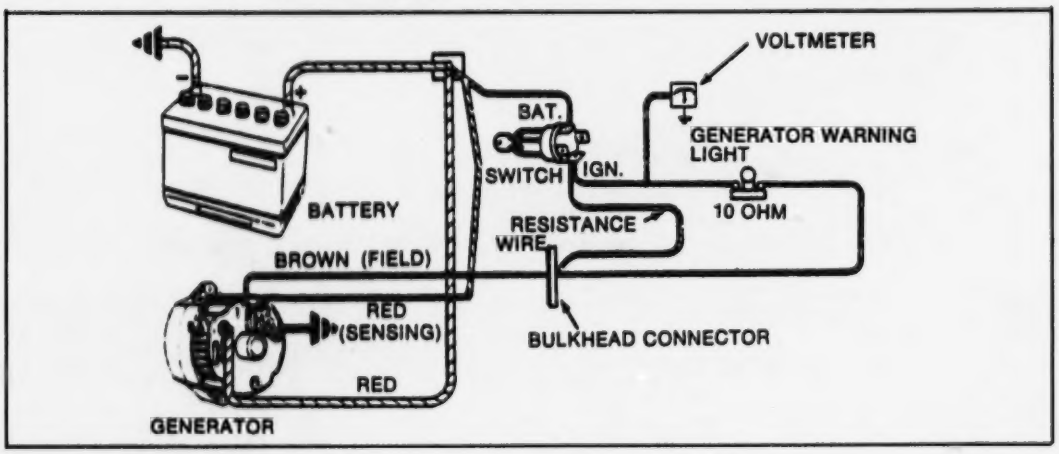


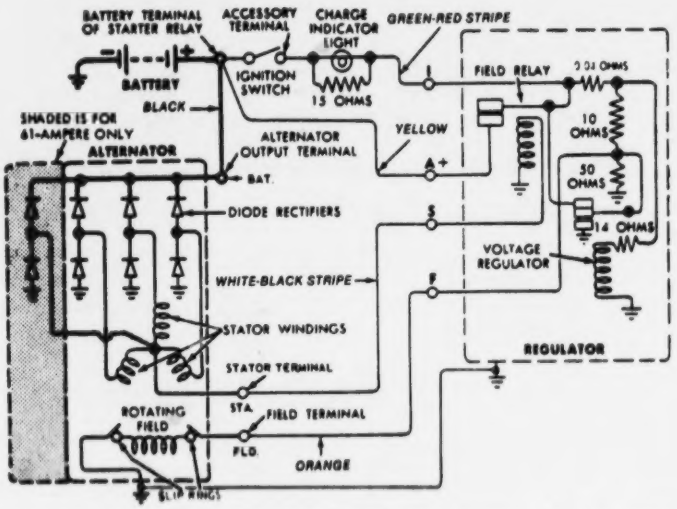
Used with permission of General Motors Corporation, Buick Motor Division.

Pictorial diagrams use drawings to represent parts and components in the circuit. On some diagrams, the drawings are labeled, while on others they are not. Notice that in the pictorial diagram shown below even the connecting lines have been drawn to resemble electrical wiring.



Used with permission of General Motors Corporation, Chevrolet Motor Division.

One of the most common methods used in automotive service references to show substance and power circuits is the ***schematic diagram***. As with pictorial diagrams, drawings are used in schematic diagrams to represent the elements in the circuit. However the drawings in schematic diagrams do not necessarily look like the things they represent. Instead, symbols are used. Compare the example below of a schematic diagram of an alternator charging system with the pictorial diagram on the previous page showing a generator charging system. Both circuits include the battery, ignition switch, wiring, and warning light, yet these components resemble each other very little in the two diagrams. This is because the schematic diagram uses symbols to depict the parts and components in the circuit. As a service specialist, you will become familiar with many schematic symbols. Sometimes the symbols will also be labeled, as in the example below. In other diagrams, the user will be expected to know the symbols. If you ever come across a symbol you do not recognize, do not hesitate to ask someone or to check other references. Misunderstanding a symbol on a schematic diagram such as the wiring circuit for a car's electronic system could prove to be a costly mistake.



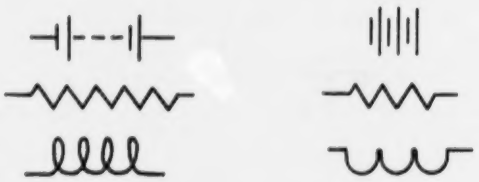
Charging system schematic with electro-mechanical regulator and charging light

Used with permission of Ford Motor Company.

Schematics

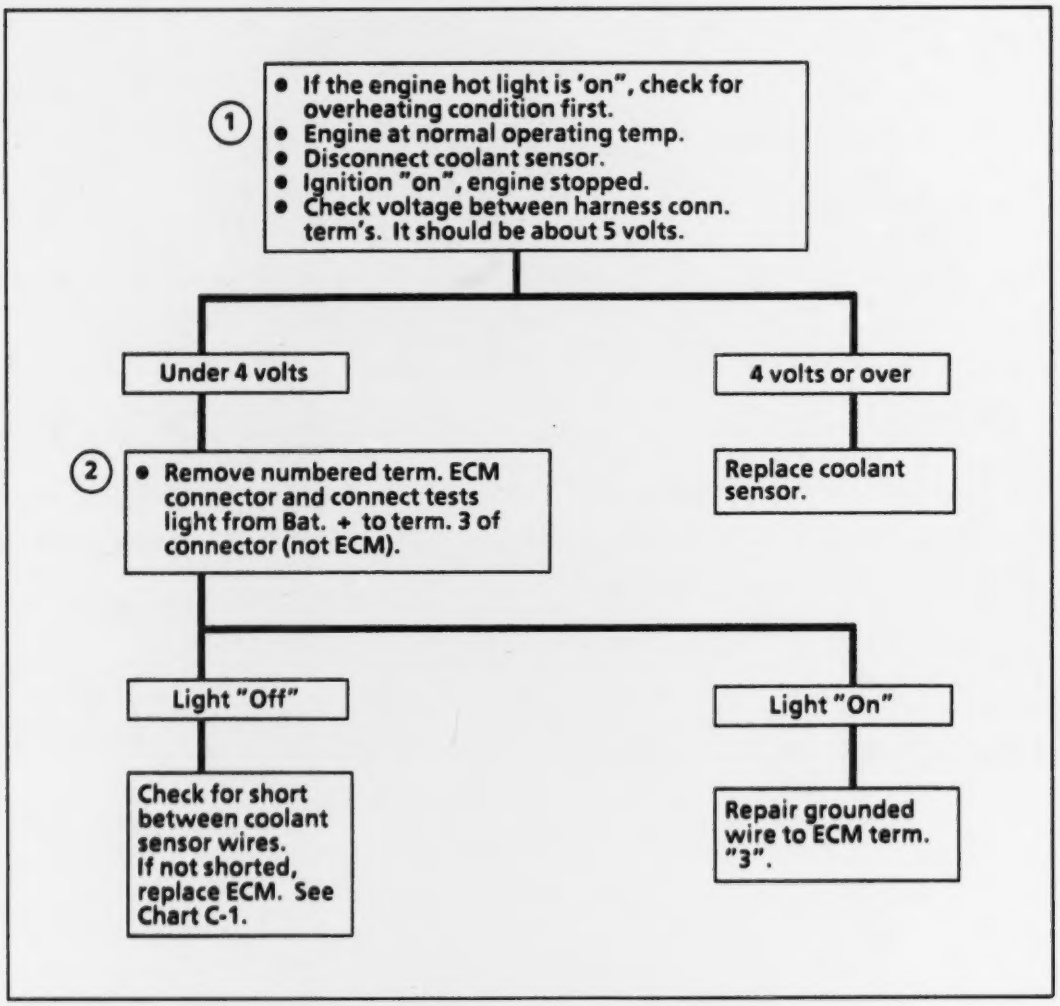
Schematic diagrams use symbols to show parts and components in the systems they represent. There are many different scientific or technical areas. For example, electrical schematics use one set of symbols, while hydraulic and pneumatic schematics use other symbols. Such symbols normally follow standards set by organizations or regulating agencies such as the National Electrical Code. However, even standardized symbols undergo updating, and the symbols used on one schematic may be slightly different from those on another schematic. The alternator circuit shown on the previous page uses some older symbols, which have been changed to the following:

Old New



The service specialist is, of course, likely to find both old and new.

The final type of diagram is called a ***flow diagram***. As was noted earlier, the flow diagram differs in purpose from the other three types of diagrams. Flow diagrams normally show a sequence of actions, either those to be done by a service specialist or those that occur in an operational sequence. Flow diagrams provide a clear summary of such steps, which is a major reason for using them. Equally important, though, is the ease with which alternative paths can be shown on a flow diagram. This is done through what are known as ***branches***. A branch is created when more than one possibility exists for a step in the sequence. For example, the flow diagram on the following page shows the sequence of steps for the service specialist to follow for a problem that can occur in the coolant sensor circuit. The first box lists several steps and conditions for doing the procedure. The last item in the box requires the service specialist to check the voltage between the harness connector terminals. The next action depends on the voltage reading. Thus, the diagram branches. If the voltage is under 4 volts, the service specialist would continue the procedure with the box labeled (2). If the voltage is 4 or more volts, the specialist would follow the other branch and replace the coolant sensor.


1
• If the engine hot light is 'on", check for overheating condition first.
• Engine at normal operating temp.
• Disconnect coolant sensor.
• Ignition "on", engine stopped.
• Check voltage between harness conn. term's. It should be about 5 volts.
Under 4 volts
4 volts or over
2
• Remove numbered term. ECM connector and connect tests light from Bat. + to term. 3 of connector (not ECM).
Replace coolant sensor.
Light "Off"
Light "On"
Check for short between coolant sensor wires. If not shorted, replace ECM. See Chart C-1.
Repair grounded wire to ECM term. "3".

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As service procedures and vehicle operation have become more complex, the use of flow diagrams has increased. The use of other types of diagrams has also increased, largely because of greater use of electrical, electronic, pneumatic, and hydraulic systems in today's vehicles. As a result, you can expect to work with diagrams often in your career in automotive service.

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

SUPPLEMENT 5 Interpreting Tables

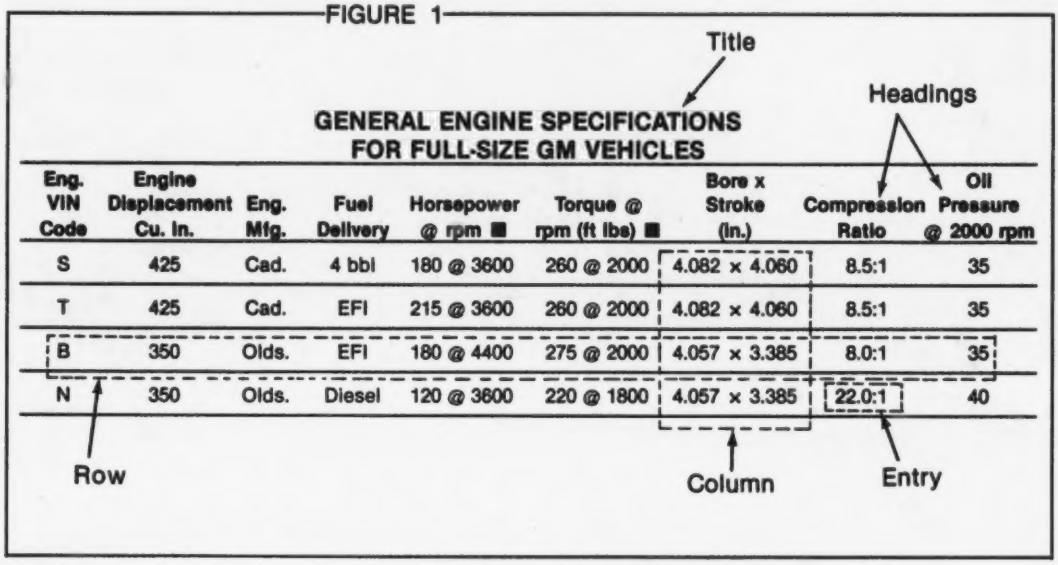
INTRODUCTION

Tables are a way to organize information so that it is easy to find. They are especially useful when the same type of information is to be given for a number of different objects or situations. For example, a table may be used to list the standard engine sizes for each Chevrolet model in a given year.

PARTS OF A TABLE

To understand how to read a table, it will be helpful for you to understand how tables are designed. Figure 1 below shows the parts of a typical table.

FIGURE 1



Eng. VIN Code	Engine Displacement Cu. in.	Eng. Mfg.	Fuel Delivery	Horsepower @ rpm ■	Torque @ rpm (ft lbs) ■	Bore x Stroke (in.)	Compression Ratio	Oil Pressure @ 2000 rpm
S	425	Cad.	4 bbl	180 @ 3600	260 @ 2000	4.082 x 4.060	8.5:1	35
T	425	Cad.	EFI	215 @ 3600	260 @ 2000	4.082 x 4.060	8.5:1	35
B	350	Olds.	EFI	180 @ 4400	275 @ 2000	4.057 x 3.385	8.0:1	35
N	350	Olds.	Diesel	120 @ 3600	220 @ 1800	4.057 x 3.385	22.0:1	40

Adapted from *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

This table shows general engine specifications for certain General Motors Corporation vehicles. This fact is apparent from the title of table. Tables are often numbered, and this numbering may be part of the title. Tables are organized into ***rows*** and ***columns***. A row is information listed horizontally or across the page. A column is information listed vertically or up and down the page. Columns generally are identified by ***headings*** that tell the type of information contained in the column. For example, the first column in the above table (the column farthest to the left) lists engine codes in the vehicle identification number (Eng. VIN Code). The first column in a table is particularly important because it shows how the rows of information are organized. All the information in the row will be related to the information in the first column.

READING A TABLE

Tables are created by listing a set of objects or situations or other information in the first column. Each bit of information in a table is called an ***entry***. The entries in each column match the entry in the first column. Each entry also provides the information identified by the heading for that particular column.

To read a table, you must know which variable to use in the first column and what heading identifies the information you need. Look again at Figure 1 on the previous page. For example, if you are working on a vehicle with an engine code of T and you want to find out the compression ratio for that engine, you would find the engine code in the first column. T is the second engine code from the top of the first column, marking the second row. By following the row across to the column marked "Compression Ratio," you will find the compression ratio for a T engine code. The compression ratio for a T engine code is 8.5:1.

Tables often have notes or other indicators to show differences between the entries and specific applications. Table 1 has five numbered notes, which apply to different parts of the table. Note 1 is information about the first column and tells where the carburetor part number can be found. Notes 2 and 4 are the entries that would go in two of the columns. They are given in notes because they are too lengthy to include in the table. Note 3 clarifies that the accelerator pump adjustment is done in position 2. The last note shows that the fast-idle entry for a 1982 R-9695A model carburetor is different (2000 rpm) than that of other models. You must be careful when working with tables to check for notes and other indicators that may affect how the table is to be interpreted.

TABLE 1

MODEL 6145 CARBURETOR
(Chrysler Corporation)

Year	Carb. Part No. ①	Float Level (In.)	Accelerator Pump Adjustment (In.)	Bowl Vent Clearance (In.)	Fast Idle (rpm)	Choke Unloader Clearance (In.)	Vacuum Kick (In.)	Fast Idle Cam Position (In.)	Choke
'81	R-9129A	②	1.615③	④	2000	.250	.150	.090	Fixed
'82	R-9936A	②	1.616③	④	1950	.250	.150	.090	Fixed
	R-9695A	②	1.615③	④	1950⑤	.250	.150	.090	Fixed
'83	R-40042A	②	1.615③	④	2000	.250	.150	.090	Fixed

① Located on a tag attached to the carburetor
② Flush with the top of the main body casting to .050" above
③ Position #2
④ Not Adjustable
⑤ Cordoba and Mirada—2000 rpm

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

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TYPES OF TABLES

Table 1 and the table shown in Figure 1 in this supplement are known as ***specification tables***. They provide specifications for specific components of particular makes and models of vehicles. Specification tables may also provide information about specific service procedures.

Two other types of tables are commonly used in automotive service reference materials. Table 2 is an ***application table***. An application table uses symbols such as Xs, check marks, and dots to show when a column applies to a row. For example, Table 2 shows that the crankcase ventilation system must be serviced at 15,000 miles, 30,000 miles, and 45,000 miles. On an application table, if a column is not marked, it does not apply for that row. Some application charts use a variety of symbols with different meanings for different symbols.

TABLE 2

Scheduled Maintenance Services For 6.2L Diesel-Fueled Vehicle

SCHEDULE II

Follow Schedule II if none of the above conditions apply and, as a general rule, you drive your vehicle daily:

- For a minimum of 15 miles (25 kilometers) or more; or
- Continuously for 30 minutes or more.

ITEM NO.	TO BE SERVICED	WHEN TO PERFORM Miles (kilometers) or Months, Whichever Occurs First	The services shown in this schedule up to 45,000 miles (75 000 km) are to be performed after 45,000 miles at the same intervals								
		MILES (000)	5	10	15	20	25	30	35	40	45
		KILOMETERS (000)	8	16	24	32	40	48	56	64	72
1	Engine Oil & Filter Change*	Every 5,000 Miles (8 000 km) or 12 Months	•	•	•	•	•	•	•	•	•
2	Chassis Lubrication	See Explanation for service intervals									
3	Exhaust Pressure Regulator Valve Inspection*	At 5,000 Miles (8 000 km), then every 15,000 Miles (24 000 km)	•		•			•			•
4	Engine Idle Speed Check*	At 5,000 Miles (8 000 km), then at 30,000 Miles (48 000 km)	•1					•1			
5	Crankcase Ventilation System Inspection*	Every 12 Months or 15,000 Miles (24 000 km)			•			•			•
6	Cooling System Service*	Every 24 Months or 30,000 Miles (48 000 km)						•			
7	Front Wheel Bearing Repack	Every 30,000 Miles (48 000 km)						•			
8	Transmission Service	See Explanation for service intervals									
9	Air Cleaner Element Replacement*	Every 30,000 Miles (48 000 km)2						•1			
10	Thermostatically Controlled Engine Cooling Fan Check▲	Every 12 Months or 10,000 Miles (16 000 km)		•		•		•		•	
11	Shields and Underhood Insulation Inspection▲	Every 10,000 Miles (16 000 km)		•		•		•		•	
12	Air Intake System Inspection▲	Every 10,000 Miles (16 000 km)		•		•		•		•	

FOOTNOTES:

1 In California, these are the minimum Emission Control Maintenance Services an owner must perform according to the California Air Resources Board. General Motors, however, urges that all Emission Control Maintenance Services shown above be performed. To maintain your other new-vehicle warranties, all services shown should be performed.

2 For engines with Engine Family FGM06.2DBAO, replace element every 15,000 miles (24 000 km).

* An Emission Control Service.

▲ Also a Noise Emission Control Service (Applicable only to vehicles with Engine Family FGM06.2DBAO and sold in the United States).

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Table 3 shows an ***indication-response table***. This type of table is used to show what the service specialist must do to correct a malfunction. For example, if a Type 400 transmission is shifted into DRIVE and the vehicle should move but doesn't, there are five possible causes of this problem related to the transmission. One possible cause is low oil level. The service specialist's response is to check for leaks, especially for a porous casting, damaged seals, or defective diaphragm in the vacuum modulator.

TABLE 3

TYPE 400 TRANSMISSION TROUBLE-DIAGNOSIS CHART

COMPLAINT	POSSIBLE CAUSE	CHECK OR CORRECTION
1. No drive in drive range	a. Low oil level	Leaks: porous casting, damaged seals, defective diaphragm in vacuum modulator
	b. Manual linkage	Readjust
	c. Low oil pressure	Check filter O ring, filter for blockage, pump, pressure regulator, case porosity
	d. Forward clutch not applying	Piston cracked, seals damaged, plates burned, leak in feed circuit, clutch ball check stuck
	e. Roller clutch damaged	Check for broken spring or damaged cage
2. 1-2 shift at full throttle only	a. Detent switch sticking or defective	Replace
	b. Detent solenoid loose or sticking	Tighten, check gasket; replace if defective
	c. Valve body	Check for loose mount, defective gasket, stuck detent valve train, 3-2 valve sticking
	d. Case porosity	Repair, replace
3. First speed only; no upshift	a. Governor assembly	Governor valve sticking, drive gear loose
	b. Valve body	1-2 valve stuck, feed channel blocked, valve body leaking due to loose bolts, gasket defect

Adapted and reprinted with permission of McGraw-Hill Book Company, Gregg Division, from *Automotive Transmissions and Power Trains*, 5th ed., by William H. Crouse and Donald L. Anglin, 1976.

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SUPPLEMENT 6

Troubleshooting

One of the most important tasks required of an automotive service specialist is determining what is wrong with a vehicle, why it will not work as it is supposed to. Although the service specialist will spend time performing routine service such as oil changes, much of the work done in an automotive shop is repair or replacement of worn, broken, or malfunctioning parts. Often the exact parts to be repaired or replaced or the exact adjustment service required will not be obvious. As you know, vehicles are complex combinations of several different but interconnected systems. As a result, most malfunctions may have more than one cause. For example, let's say the brake lights on a vehicle fail to come on when the brake pedal is depressed. What are some possible causes of this malfunction?

It is possible that both bulbs are burned out. It could be that power is not getting to the brake lights. Such an electrical failure could be due to a dead battery or a break in the wiring or a loose or corroded connection anywhere in the circuit. The circuit may be broken by a bad fuse. Another possible cause is faulty operation of the switch that is supposed to complete the brake light circuit when the brake pedal is depressed. The switch itself may be faulty or loose, or there may be a problem with the mechanical connection between the pedal and switch.

Obviously, if something as simple as an inoperative brake light can result from so many different causes, malfunctions in more complex systems may have even more complicated sources. So how does a service specialist decide what needs to be repaired if a vehicle will not start or an automatic transmission will not shift or a clunking sound is heard when the vehicle turns left at low speeds? It would be a costly waste of time to begin repairing each possible cause on a hit-and-miss basis until the problem was corrected.

A smarter way of trying to figure out what is causing a problem is to use a systematic approach to narrow down the number of possibilities. Automotive service specialists do this quite often as they ***troubleshoot*** or ***diagnose*** problems. Frequently service manuals and other reference materials provide troubleshooting charts or flow diagrams. These materials guide the service specialist through a diagnostic process that will help determine the repair requirement.

But not all troubleshooting needs are covered by charts or diagrams. However, the service specialist may still be able to approach the problem systematically by applying troubleshooting principles. Basically, troubleshooting consists of performing the following steps:

1. Verify the problem.

   - This is an information-gathering step. If a customer brings in a vehicle that is not operating correctly, you should ask questions about what the customer thinks is wrong, what the indications are, whether the indications vary, how long the problem has existed, etc.

   - Operate the vehicle yourself to see whether you experience the same problem and to gain a better understanding of the customer's description.

   - Operate the problem system in as many ways as you can. For example, suppose that a customer has reported that her windshield wipers do not work. Check the wipers with the switch in each operating position (intermittent, low, high). Check to see whether the washer system works. The more information you can gather about the problem, the more you will have to go on when you try to determine the exact cause of the problem.

   - Compare the indications you get to expected indications for a normally operating system. Is the system completely inoperative or just partially so? Does the system work fine under some conditions but not so under others? For example, if the engine surges when it idles, does it do so only when it is cold or at all temperatures? If only when cold, is that a normal indication or not?

2. Narrow the problem.

   Based on the indications, what seems to be the most likely cause of the problem? For example, if an automatic transmission operates just fine in the forward gears but will not operate in reverse, those problems that do not affect reverse and those that would always affect both reverse and forward gears can be eliminated as possibilities. That is why it is important to get as much information as possible.

3. Perform tests and inspections.
   - When testing a defective system, begin with tests that will verify the most probable cause. If the source of the problem still has not been discovered, continue testing with the next probable cause.
   - Begin with the simplest tests and inspections. Some tests and inspections are very complex and may involve removing parts, installing test equipment, and other procedures. If the problem can be isolated without all that effort, such involved procedures are a waste of time.
4. Repair the indicated problem, following the recommended service procedure including required adjustments.
5. Verify that the original problem has been solved and that no new ones have been created.
   - Operate the system under various conditions.
   - Perform tests, inspections, and measurements as needed to confirm that the problem has been corrected.

By following these simple steps, the service specialist should be able to do a fairly good job of troubleshooting vehicle-performance problems even if service manuals do not contain specific troubleshooting guidelines for the problem encountered.

TESTS

There are three basic types of tests and inspections. The most common is the ***visual inspection***. Simply look everything over. Check for leaks, loose or misaligned parts, worn or broken components, poor electrical connections, low fluid levels, etc. Another common test is the ***substitution test***. To perform a substitution test, the service specialist removes a suspected bad part or component and substitutes one that is known to be good. If everything operates normally, then the system has been repaired. However, the service specialist must be careful again to consider additional possibilities, such as did other factors cause the part to fail? For example, if a starter fails to work, but functions fine when a known-good starter is substituted, the problem may be solved—unless this is the third starter to fail in the past few weeks. Some other problem must exist that leads to the short working life of the starters. The final type of test is the ***use of instruments to measure system performance***. Such tests may measure electrical flow, fluid or air pressure, engine speed, timed sequences, distances between parts, distances that parts travel, or many other measurements. The service specialist then compares the test readings to the normally expected readings. Variances between the actual and expected readings may indicate the source of the problem. In many cases, the service specialist must do all three types of tests and inspections when troubleshooting a malfunction.

ASSIGNMENT SHEET 1

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 3

Interpret vehicle identification numbers

Name _____ Score _____

INTRODUCTION

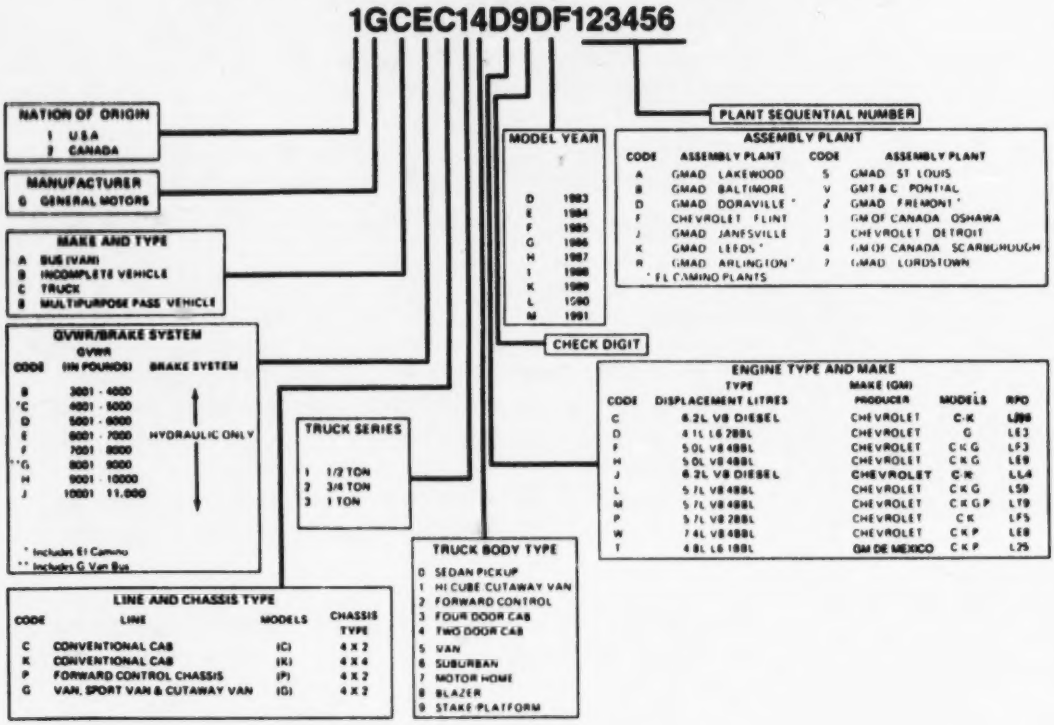
Parts vary from vehicle to vehicle even in vehicles of the same make and model. For example, a 1987 Cutlass Supreme manufactured in October 1986 may be slightly different from one produced in May 1987: The vehicle manufactured in May may require slightly different parts, such as a shorter bolt in one component, or it may be equipped differently, causing the vehicle to have different specifications. The service specialist can determine these differences and variations by checking the vehicle identification number (VIN).

Vehicles are given VINs by the manufacturer. These numbers are used in registering vehicles and for other purposes, but they are also valuable to the service specialist because of the information they provide. Most vehicle manufacturers' service manuals have a section near the front of the manual that explains how to interpret the VIN. Knowing how to read the VIN to determine correct parts and service procedures is an essential skill of the automotive service specialist. This assignment sheet will help you to better understand how the VIN is used.

VINs are easy to understand if you have the chart used by the manufacturers in producing the number. A sample chart is shown on the following page.

Each letter or number in the VIN is connected to a box by means of a line. The information in the box explains the meaning of the number or letter to which it is connected. For example, the seventh digit is the body-type code. The number is a 4, which identifies this vehicle as a two-door cab. Other manufacturers may use different types of charts, but each will explain the meaning of the letters and numbers in each position of the VIN.

VEHICLE IDENTIFICATION NUMBER


1GCEC14D9DF123456
NATION OF ORIGIN
1 USA
2 CANADA
MANUFACTURER
G GENERAL MOTORS
MAKE AND TYPE
A BUS (VAN)
B INCOMPLETE VEHICLE
C TRUCK
D MULTIPURPOSE PASS VEHICLE
GVWR/BRAKE SYSTEM
GVWR
CODE (IN POUNDS) BRAKE SYSTEM
B 3001 - 4000
*C 4001 - 5000
D 5001 - 6000
E 6001 - 7000
F 7001 - 8000
**G 8001 - 9000
H 9001 - 10000
J 10001 - 11,000
HYDRAULIC ONLY
* Includes El Camino
** Includes G Van Bus
LINE AND CHASSIS TYPE
CODE LINE MODELS CHASSIS TYPE
C CONVENTIONAL CAB (C) 4 X 2
K CONVENTIONAL CAB (K) 4 X 4
P FORWARD CONTROL CHASSIS (P) 4 X 2
G VAN, SPORT VAN & CUTAWAY VAN (G) 4 X 2
TRUCK SERIES
1 1/2 TON
2 3/4 TON
3 1 TON
TRUCK BODY TYPE
0 SEDAN PICKUP
1 HI CUBE CUTAWAY VAN
2 FORWARD CONTROL
3 FOUR DOOR CAB
4 TWO DOOR CAB
5 VAN
6 SUBURBAN
7 MOTOR HOME
8 BLAZER
9 STAKE PLATFORM
MODEL YEAR
D 1983
E 1984
F 1985
G 1986
H 1987
J 1988
K 1989
L 1990
M 1991
CHECK DIGIT
PLANT SEQUENTIAL NUMBER
ASSEMBLY PLANT
CODE ASSEMBLY PLANT CODE ASSEMBLY PLANT
A GMAD LAKEWOOD 5 GMAD ST LOUIS
B GMAD BALTIMORE V GMT & C PONTIAC
D GMAD DORAVILLE * 4 GMAD FREMONT *
F CHEVROLET FLINT 1 GM OF CANADA OSHAWA
J GMAD JANESVILLE 3 CHEVROLET DETROIT
K GMAD LEEDS * 4 GM OF CANADA SCARBOROUGH
R GMAD ARLINGTON * 7 GMAD LORDSTOWN
* EL CAMINO PLANTS
ENGINE TYPE AND MAKE
TYPE MAKE (GM)
CODE DISPLACEMENT LITRES PRODUCER MODELS RPO
C 6.2L V8 DIESEL CHEVROLET C-K L20
D 4.1L L6 2BBL CHEVROLET G LE3
F 5.0L V8 4BBL CHEVROLET C-K-G LF3
H 5.0L V8 4BBL CHEVROLET C-K-G LE9
J 6.2L V8 DIESEL CHEVROLET C-K LL4
L 5.7L V8 4BBL CHEVROLET C-K-G L59
M 5.7L V8 4BBL CHEVROLET C-K-G-P LT9
P 5.7L V8 2BBL CHEVROLET C-K LF5
W 7.4L V8 4BBL CHEVROLET C-K-P LE8
T 4.8L L6 1BBL GM DE MEXICO C-K-P L25

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DIRECTIONS

Sample vehicle identification numbers for various vehicles are listed on the following pages. Use the appropriate service manuals to interpret the VINs and to answer the questions following each.

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1. 1986 Chrysler New Yorker with VIN 1C3BT56K7GX377918

   a. In what plant was this vehicle assembled?

   _____

   b. What size of engine is in this vehicle?

   _____

   c. If you had to raise this vehicle on a frame-contact hoist, how far from the center of the rear axle should the hoist pad be positioned?

   _____ inches

   d. How much coolant will the cooling system hold?

   _____ quarts or _____ liters

   e. What must be done to allow additional ground clearance when towing this vehicle from the front?

   _____

   _____

2. 1986 Chevrolet pickup with VIN 1GCDC14N4GF173309

   a. What size of engine is in this vehicle?

   _____

   b. What is the gross vehicle weight rating (GVWR)?

   _____

   c. If you change the oil and filter, how much oil is required to fill the crankcase?

   _____ quarts or _____ liters

   d. Firing order refers to the sequence of cylinders in which the spark plug ignites the compressed fuel. Each cylinder is numbered, and firing order is written as the sequence of firing in those cylinders. What is the firing order for this pickup?

   _____

e. To compress the valve springs on the cylinder heads of this engine, a special tool, called a *spring compressor*, is required. What is the number of the spring compressor that should be used?

_____

3. 1980 Ford Country Squire station wagon with VIN 0S76G397062

a. Because of the design of the oil pan on this vehicle, some special action that is not required on most vehicles is required on this vehicle when draining the oil. What is that action?

_____

_____

b. What is the firing order of the engine in this vehicle?

_____

c. What is the capacity of the fuel tank?

_____ gallons

d. How many catalytic converters are used in this vehicle's exhaust system?

_____

e. This vehicle is equipped with a dual-action tailgate—the tailgate can be opened like a door or lowered like a pickup tailgate. If you had to install weatherstripping for the tailgate, where would you begin the installation?

_____

ASSIGNMENT SHEET 2	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 4

Interpret illustrations used in automotive service reference materials

Name _____ Score _____

INTRODUCTION

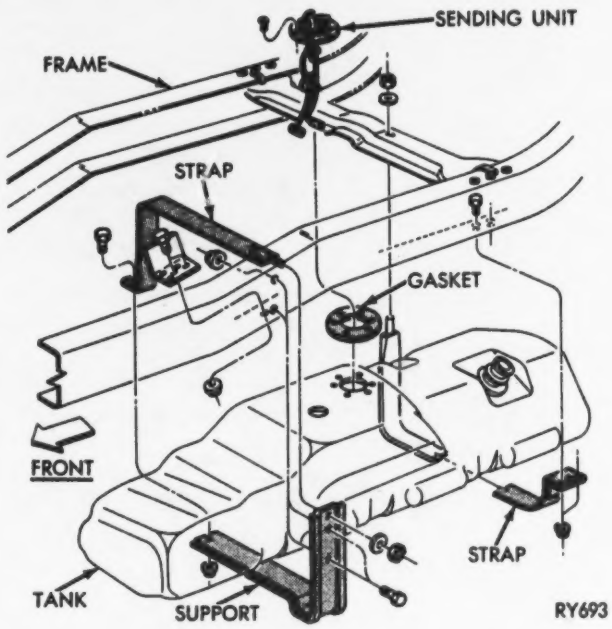
Illustrations are used in automotive service reference materials to clarify written explanations or instructions. An illustration may be a drawing, a photograph, or a combination of the two. Illustrations show the service specialist how parts fit together and how certain procedures are to be performed. Illustrations can be a great aid in understanding reference materials. To understand these illustrations, however, the service specialist must understand the guidelines and principles used in producing those illustrations (see Student Supplement 2).

DIRECTIONS

Study each of the illustrations on the following pages, and answer the questions with each. Write your answers on the lines provided or write an "X" in the blanks before the correct answers. It is not necessary for you to understand how the illustrated items work to answer the questions. You only need to understand what the illustrations show.

1. The following illustration shows how the fuel tank is attached on one make and model of pickup.

   NOTE: These materials and most references determine left and right in terms of what those directions would be for someone sitting in the driver's seat. Thus, in most U.S.-built vehicles the steering wheel is on the left side of the vehicle.



Used with permission of Chrysler Corporation.

   a. When attached, is the fuel tank on the left or right side of the vehicle frame?

   _____

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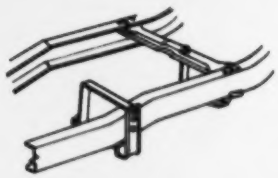
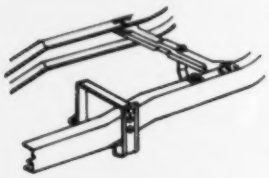
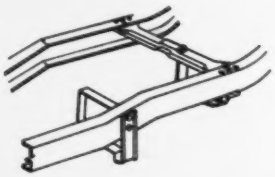
b. Which of the following drawings best illustrates how the straps and supports will look when assembled?

NOTE: The fuel tank has been omitted in all of the drawings.

_____1) 

_____2) 

_____3) 

c. When installed, to which of the following is the sending unit attached?

_____1) The tank

_____2) The frame

_____3) The rear strap

_____4) Both 1 and 2

2. The illustration on the next page shows an exploded view of an air-conditioner compressor. Notice that not all bolts are shown, but only one of each type. Notice also that the compressor uses a piston and crankshaft much like an internal combustion engine.

a. List the parts that are involved in assembling the piston and connecting it to the crankshaft.

NOTE: The part labeled *ring* goes on the piston, and two bolts are used.

_____

_____

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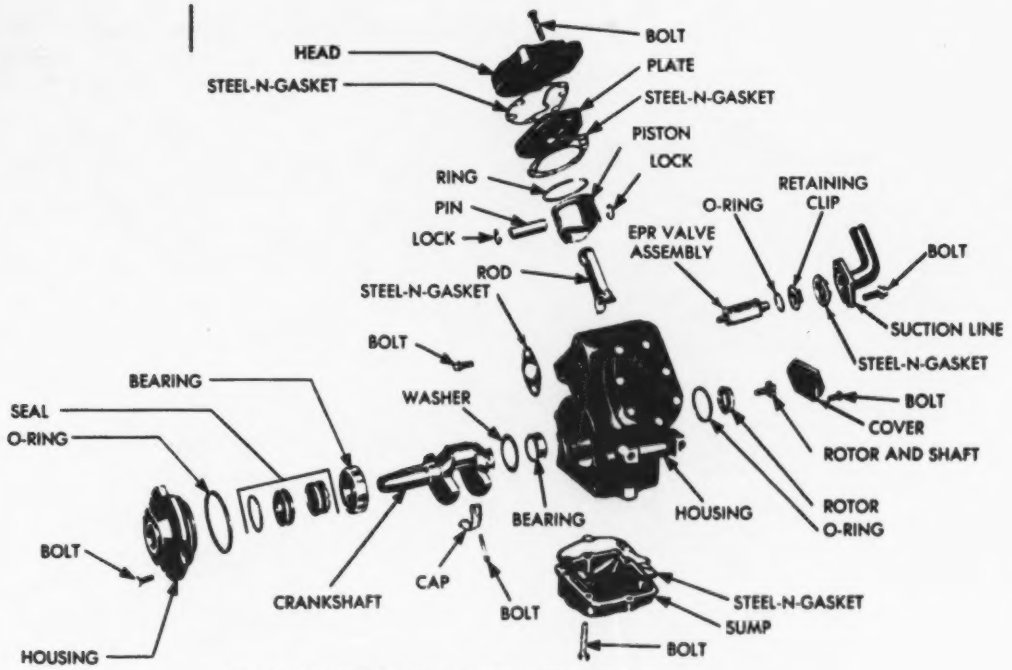

Used with permission of Chrysler Corporation.

b. Which of the following is the correct sequence of placing parts on the housing when attaching the head?

_____1) Steel-n-gasket, plate, head

_____2) Head, steel-n-gasket, plate, steel-n-gasket

_____3) Head, steel-n-gasket, plate

_____4) Steel-n-gasket, plate, steel-n-gasket, head

c. Which of the following best describes the relationship between where the suction line connects to the housing and where the cover for the rotor and shaft assembly attaches to the housing?

_____1) The line attaches above the cover

_____2) The line attaches below the cover

_____3) The line attaches at the side of the cover toward the rear of the housing as shown

_____4) The line attaches at the side of the cover toward the front of the housing as shown

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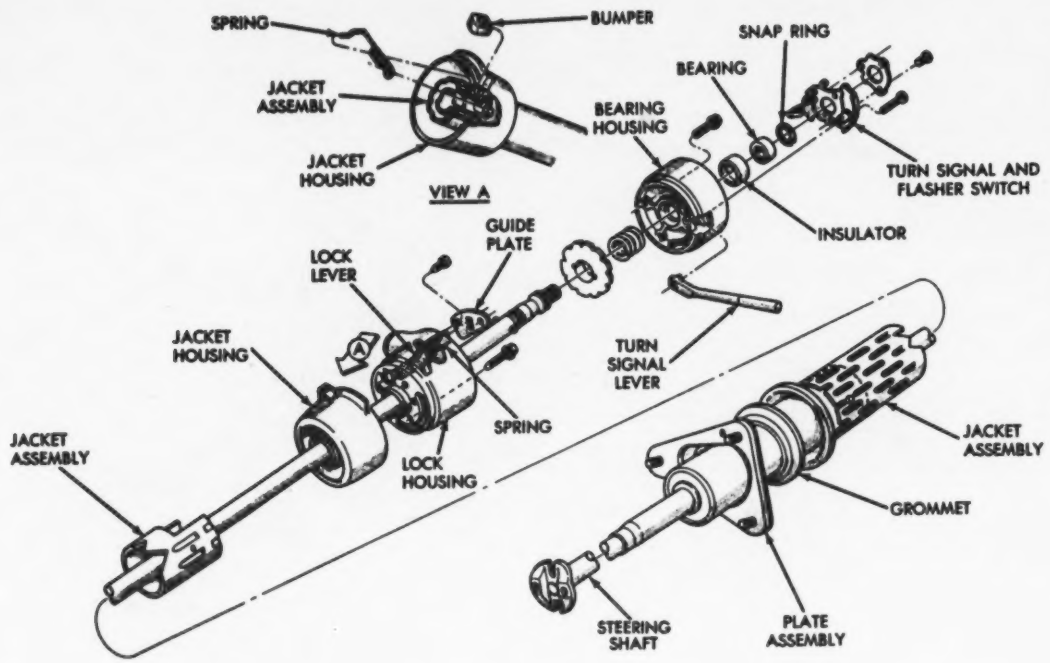
3. The illustration below shows how a steering column with a stick-shift is assembled for one make and model of vehicle.



Used with permission of Chrysler Corporation.

a. What part does the turn-signal lever fit into?

_____

b. What does View A show?

_____1) The end of the jacket assembly facing the driver

_____2) The end of the jacket assembly that points away from the driver

_____3) The end of the jacket housing facing the driver

_____4) Both 1 and 3

c. What is the last (uppermost) part labeled in the illustration that fits over the steering shaft?

_____

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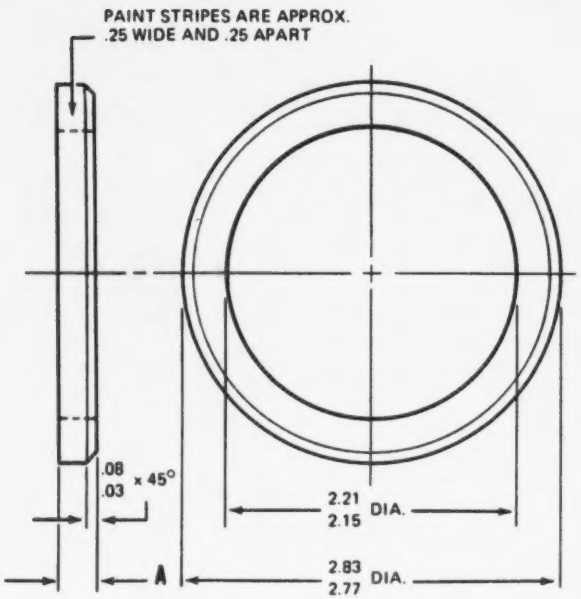
4. The illustration and table below explain how to determine what shim to use when assembling a family of vehicle differentials. A *shim* is a part used to provide proper spacing for other parts.



NUMBER OF STRIPES AND COLOR CODE	DIM. A
2 – C-COAL	.3070 – .3075
1 – C-COAL	.3050 – .3055
5 – BLU	.3030 – .3035
4 – BLU	.3010 – .3015
3 – BLU	.2990 – .2995
2 – BLU	.2970 – .2975
5 – PINK	.2930 – .2935
4 – PINK	.2910 – .2915
3 – PINK	.2890 – .2895
2 – PINK	.2870 – .2875
1 – PINK	.2850 – .2855
5 – GRN	.2830 – .2835
4 – GRN	.2810 – .2815
3 – GRN	.2790 – .2795
2 – GRN	.2770 – .2775
1 – GRN	.2750 – .2755
5 – WH	.2730 – .2735
4 – WH	.2710 – .2715
3 – WH	.2690 – .2695
2 – WH	.2670 – .2675
1 – WH	.2650 – .2655
5 – YEL	.2630 – .2635
4 – YEL	.2610 – .2615
3 – YEL	.2590 – .2595
2 – YEL	.2570 – .2575
1 – YEL	.2550 – .2555
5 – ORNG	.2530 – .2535
4 – ORNG	.2510 – .2515
3 – ORNG	.2490 – .2495
2 – ORNG	.2470 – .2475
1 – ORNG	.2450 – .2455
2 – RED	.2430 – .2435
1 – RED	.2410 – .2415

Used with permission of Ford Motor Company.

a. Which of the following are possible inside diameters of this shim? There may be more than one correct answer.

_____1) 2.16 _____3) 2.22

_____2) 2.77 _____4) 2.20

b. When reassembling the differential, you find that you need a shim that is .2613 inches thick. What color and how many paint stripes will be on the shim?

_____

c. What is the maximum thickness of a shim with two red stripes?

_____

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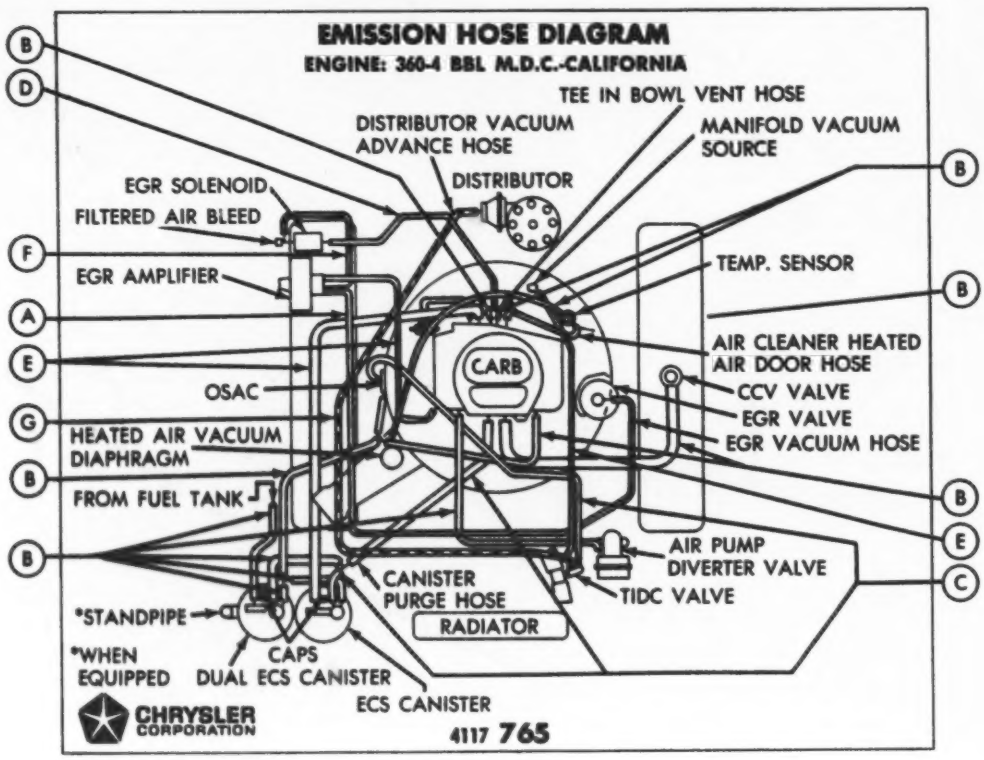
5. The illustration below shows the hoses used in the emission-control system of a Chrysler V-8 engine with California emission equipment.



(A) WHITE
(B) BLACK
(C) RED-SOLID
(D) TAN
(E) YELLOW
(F) ORANGE
(G) RED-DASHED

Used with permission of Chrysler Corporation.

a. What color is the hose between the fuel tank and the dual ECS canister?

_____

b. What color is the distributor vacuum advance hose?

_____

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c. What color is the EGR vacuum hose?

_____

d. What color is the canister purge hose?

_____

e. The yellow hose attached at one end to the manifold vacuum source should be attached to what at the other end?

_____

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ASSIGNMENT SHEET 3

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 5

Interpret graphs used in automotive service reference materials

Name _____ Score _____

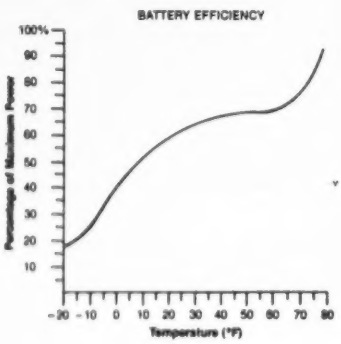
INTRODUCTION

Automotive service specialists work with a great deal of numerical information. Numbers are used to give measurements of such things as distance, time, pressure, volume, and sizes. Numbers describe sequence, quantities, and many other values. Often, the quantities with which the automotive service specialist is concerned are quantities that change. These changing quantities may best be represented on graphs. Graphs are convenient ways of showing how such changes relate to each other (see Student Supplement 3). Automotive service reference materials commonly use graphs to provide information in an easy-to-understand form.

DIRECTIONS

Study the following graphs, and answer the questions with each.

1. The graph to the right shows battery efficiency in relation to changes in temperature. The graph shows that, as the outside temperature increases or decreases, the amount of power from the battery, in terms of its greatest possible power, changes.



   a. Generally, does the amount of power produced by the battery increase or decrease as the temperature drops?

   _____

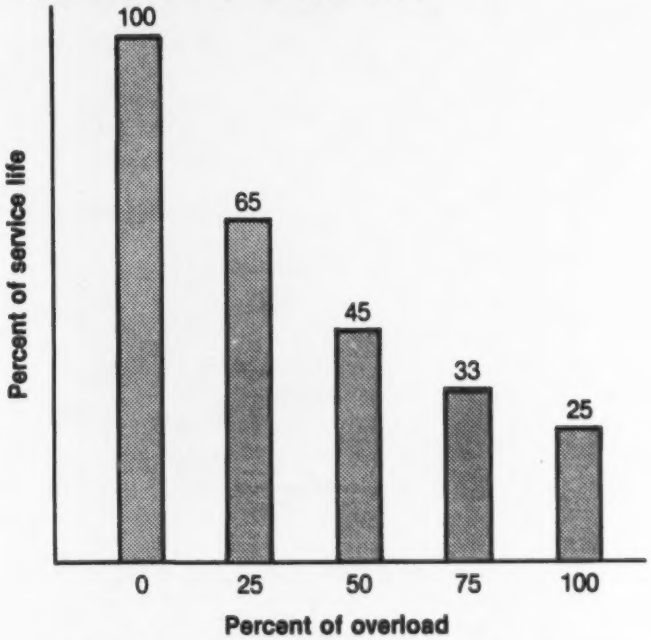
   b. Is the change in temperature shown on the vertical (up and down) axis or the horizontal (across) axis?

   _____

c. What unit of measure is used to show the temperature?

d. What is the approximate efficiency of the battery if the outside temperature is 60°F?

2. The bar graph below compares tire service life to load ratings. The load rating of a tire is the amount of weight the tire has been designated to carry, while service life is the number of miles that a tire can be used safely.

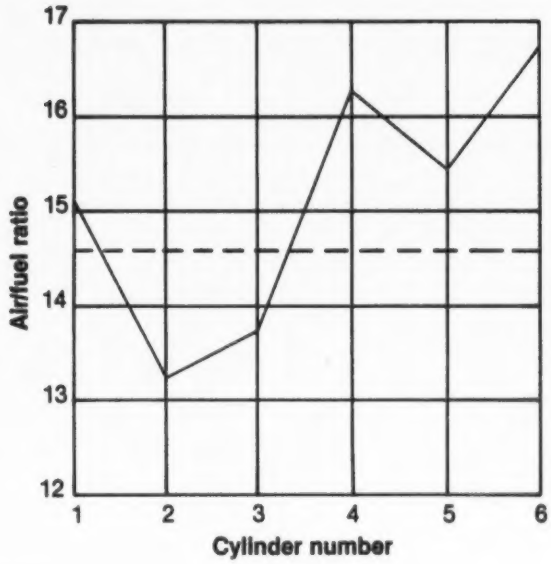


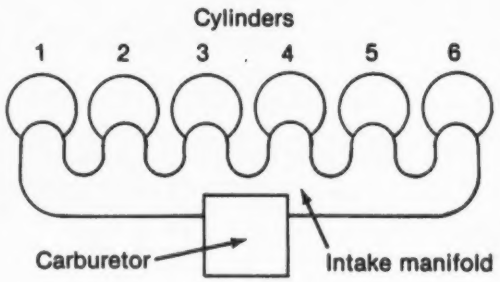
a. What happens to tire service life as the amount of overload increases?

b. If a set of tires with a service life of 40,000 miles is driven under twice the load-rated weight, how many miles can the tires be expected to last?

c. Driving with an overload of 25 percent reduces the service life to what percentage?

3. Below is a numerical graph showing air/fuel ratios at the six cylinders of an engine. The dashed line shows that the air/fuel mixture leaving the carburetor was 14.7 parts of air for every part of fuel (by weight). The illustration to the right of the graph shows the design of the intake manifold and the cylinders.





a. Does the air/fuel mixture reaching cylinder 3 have a higher or lower percentage of fuel than that reaching cylinder 4?

_____

b. Air/fuel mixtures are referred to as *rich* or *lean*: The higher the percentage of fuel, the *richer* the mixture; the lower the percentage of fuel, the *leaner* the mixture. Which cylinder is getting the richest air/fuel mixture?

_____

c. Studies on this design of intake manifold have shown that the force with which the air/fuel mixture exists the carburetor tends to carry fuel past the cylinders nearest the carburetor. However, the heavier fuel particles then slow down at a faster rate than the air particles. What feature shown on the chart is explained by these study results?

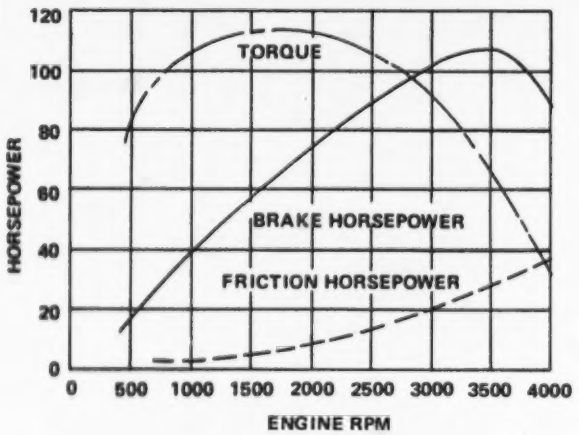
_____

_____

750

4. The power produced by an engine is measured in *horsepower* (hp). You can learn some general concepts about engine power by studying the graph below. The curve labeled *brake horsepower* shows the amount of power actually put out by the engine at various engine speeds, or rpm (revolutions per minute). This measure is called *brake horsepower* because the device used to measure power output uses a brake to drag down the engine. The lower dashed line shows the total amount of power lost to friction—that is, the power produced by the engine that is used up just moving the engine parts.

   The upper dashed line shows engine *torque*. Torque is a measure of turning power. In the graph, the torque curve shows how much power is produced by the turning crankshaft. The quantities represented on this graph are typical for one vehicle only. Different engines and different vehicles would produce different graphs.



Reprinted with permission of McGraw-Hill Book Company, Gregg Division, from *Automotive Mechanics*, 9th ed., by William H. Crouse and Donald L. Anglin, 1985.

   a. The faster the crankshaft turns, the faster the four-cycle combustion process occurs. As a result, each cycle has less time to take place. At high engine speeds, for example, the intake valve is not open long enough for the combustion chamber to fill completely with air/fuel mixture. Because there is less fuel to burn, the force produced by ignition is less. Therefore, fewer horsepower are available on the power stroke to drive the connecting rod down and turn the crankshaft. What feature of the graph shows this effect?

_____

_____

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b. Does the amount of power lost to friction increase or decrease as engine speed increases?

_____

c. The power that is developed in the combustion chamber is referred to as *indicated horsepower.* Indicated horsepower is the sum of the engine output (brake horsepower) and the power lost to friction (friction horsepower), or

Indicated hp = Brake hp + Friction hp.

According to the graph, what is the approximate indicated horsepower at each of the following engine speeds?

1) 1000 rpm — _____
2) 2000 rpm — _____
3) 3000 rpm — _____
4) 4000 rpm — _____

ASSIGNMENT SHEET 4	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 6

Interpret diagrams used in automotive service reference materials

Name _____ Score _____

INTRODUCTION

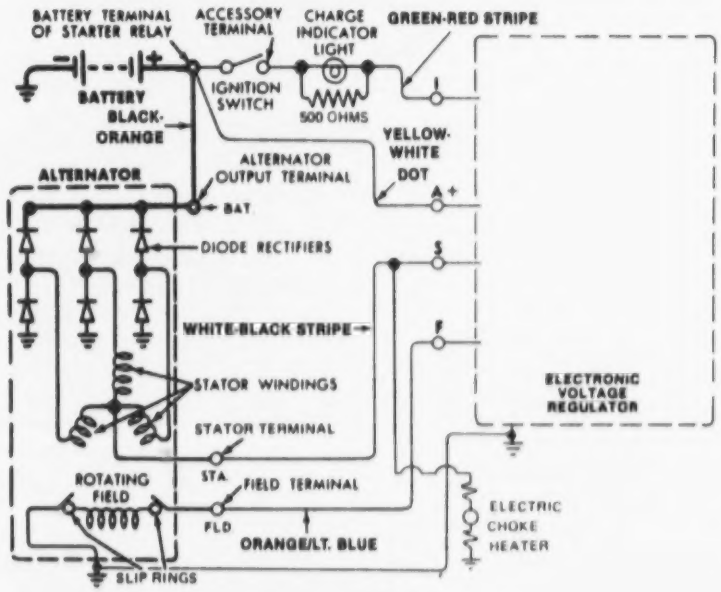
The complex systems in today's vehicles require simple methods of showing how the parts are connected and how they function. Diagrams are used for this purpose. Diagrams are also used to show sequences of events and the flow of energy or substances (see Student Supplement 4). Through the use of symbols, diagrams make it much easier to show complex relationships. This assignment sheet will allow you to practice using diagrams.

DIRECTIONS

Study each of the diagrams on the following pages, and answer the questions with each. Write your answers on the lines provided or write an "X" in the blanks before the correct answers.

1. The following diagram shows the electrical circuit for the charging system for many Ford and Mercury vehicle models having charge indicator lights.

Alternator Charging System—Indicator Lamp



Used with permission of Ford Motor Company.

a. What color of wire runs between the field terminal on the alternator and the "F" terminal on the electronic voltage regulator?

_____

b. What color of wire runs between the stator terminal on the alternator and the "S" terminal on the electronic voltage regulator?

_____

c. What color of wire runs between the battery terminal of the starter relay and the "A+" terminal of the electronic voltage regulator?

_____

d. What color of wire runs between the battery terminal of the starter relay and the alternator output terminal?

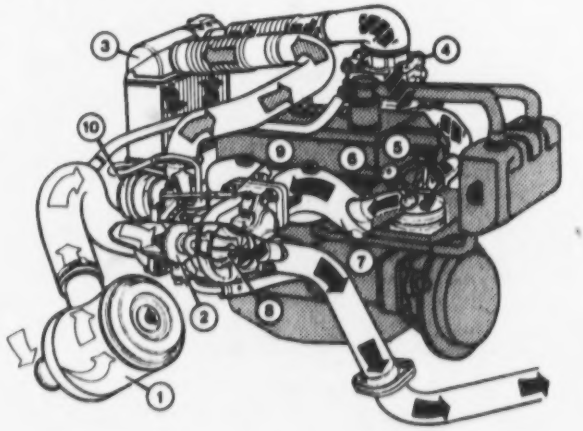
_____

e. What color of wire runs between the charge indicator light and the "I" terminal of the electronic voltage regulator?

_____

2. The following diagram shows airflow through a turbocharger.

AIR AT ATMOSPHERIC PRESSURE
PRESSURIZED CHARGE AIR
PRESSURIZED AND RECOOLED CHARGE AIR
EXHAUST GASES



1. AIR FILTER
2. COMPRESSOR ROTOR
3. CHARGE AIR INTERCOOLER
4. PRESSURIZED CARBURETOR
5. INTAKE VALVE
6. EXHAUST VALVE
7. EXHAUST MANIFOLD
8. TURBINE
9. WASTEGATE
10. WASTEGATE ACTUATOR (PRESSURE SENSOR)

Courtesy Chrysler Motors.

a. What is the pressure of air entering the air filter?

_____

b. Exhaust gases move from the exhaust valve to the turbine through what part?

_____

c. What type of air is produced by the compressor rotor?

_____

d. What type of air enters the cylinder through the intake valve?

_____

3. On the opposite page is a flowchart showing a diagnosis procedure for noise from the wheel bearing assembly.

   a. When test driving a vehicle, you hear a clattering sound at low speeds that appears to be coming from the front wheels. What are three probable sources of the noise?

   _____

   _____

   b. When you check the tires of the same vehicle, you find that all have the correct pressure. However, the right front tire is badly worn on the inside part of the tread, and the wheel rim appears to be bent. According to the flowchart, what action should you take?

   _____1) No other action is required

   _____2) Hoist the vehicle, support the lower control, and spin the wheel with the engine

   _____3) Hoist the vehicle, support the lower control, and spin the wheel with a spinner

   _____4) Replace the bent rim

   c. One of your co-workers is checking suspected bearing noise in the front wheel assembly on a 1983 Chevrolet Citation with front-wheel drive. He has the vehicle hoisted with the lower control arm supported and is running the engine to spin the wheel. You see that the speedometer reads approximately 40 mph to 45 mph. What should you do? Why?

   _____

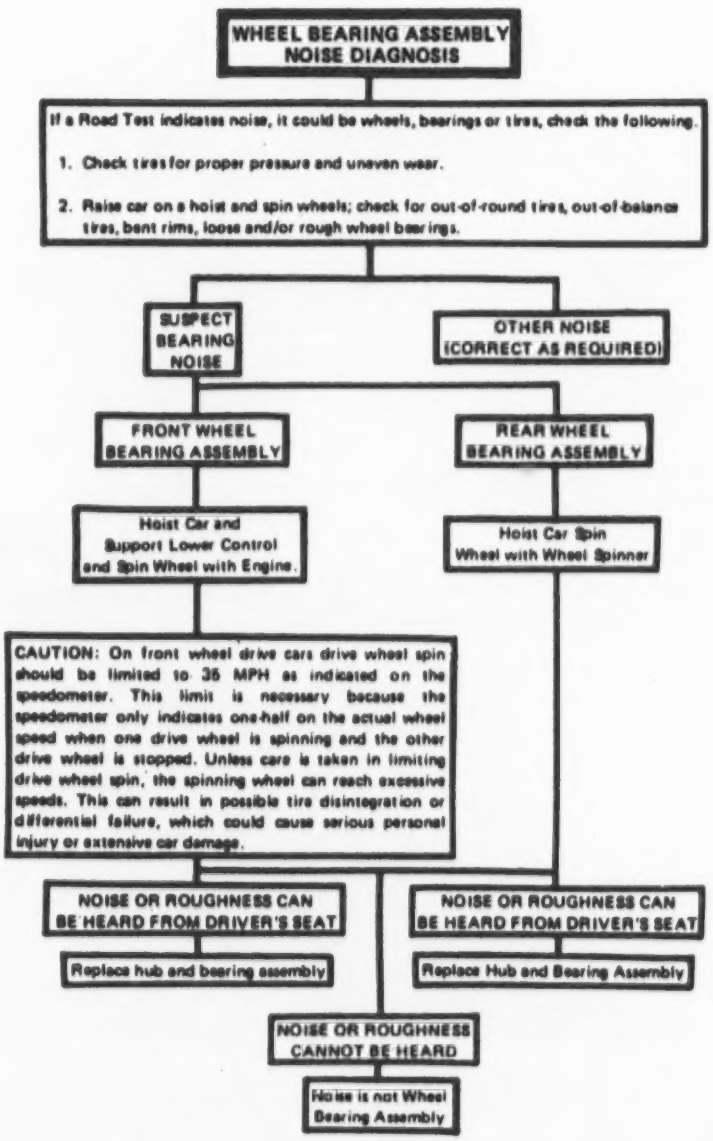
   _____

   _____

   d. When the spin test is done correctly, you can hear noise and feel some vibration when you sit in the driver's seat. What should you do to correct the problem?

   _____

   _____


WHEEL BEARING ASSEMBLY NOISE DIAGNOSIS
If a Road Test indicates noise, it could be wheels, bearings or tires, check the following.
1. Check tires for proper pressure and uneven wear.
2. Raise car on a hoist and spin wheels; check for out-of-round tires, out-of-balance tires, bent rims, loose and/or rough wheel bearings.
SUSPECT BEARING NOISE
OTHER NOISE (CORRECT AS REQUIRED)
FRONT WHEEL BEARING ASSEMBLY
REAR WHEEL BEARING ASSEMBLY
Hoist Car and Support Lower Control and Spin Wheel with Engine.
Hoist Car Spin Wheel with Wheel Spinner
CAUTION: On front wheel drive cars drive wheel spin should be limited to 35 MPH as indicated on the speedometer. This limit is necessary because the speedometer only indicates one-half on the actual wheel speed when one drive wheel is spinning and the other drive wheel is stopped. Unless care is taken in limiting drive wheel spin, the spinning wheel can reach excessive speeds. This can result in possible tire disintegration or differential failure, which could cause serious personal injury or extensive car damage.
NOISE OR ROUGHNESS CAN BE HEARD FROM DRIVER'S SEAT
NOISE OR ROUGHNESS CAN BE HEARD FROM DRIVER'S SEAT
Replace hub and bearing assembly
Replace Hub and Bearing Assembly
NOISE OR ROUGHNESS CANNOT BE HEARD
Noise is not Wheel Bearing Assembly

Used with permission of General Motors Corporation, Pontiac Motor Division.

ASSIGNMENT SHEET 5	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 7

Interpret tables used in automotive service reference materials

Name _____ Score _____

INTRODUCTION

Much of the information that the service specialist needs is contained in tables. Tables organize information so that it is easy to locate. Tables often give the same types of information for several different vehicles, model years, engines, or other variables (see Student Supplement 5). This assignment sheet will give you practice in interpreting tables.

DIRECTIONS

Study each of the following tables, and answer the questions with each. Write your answers on the lines provided or write an "X" in the blanks before the correct answers.

1. Table 1 on the following page shows the vehicle speed at which various Dodge trucks with automatic transmissions shift, depending on how the vehicle is equipped and being operated. Information is presented for four weight classes of trucks: 150, 200, 300, and 400 models. Each truck is equipped with one of three engine sizes: 225-, 318-, and 360-cubic-inch displacements (CID). The vehicle speed at which the transmission upshifts (goes from one gear to a higher one) or downshifts (goes to a lower gear) also depends on the size relationship of the gears in the rear axle (axle ratio), whether the vehicle is equipped with the factory standard size of tires, and whether the vehicle is being run with the accelerator pedal all the way to the floor (wide-open throttle) or with the accelerator pedal released (closed throttle).

TABLE 1

AUTOMATIC SHIFT SPEEDS

(APPROXIMATE MILES PER HOUR)
(km/hr. = Kilometers Per Hour)

Engine (CID)	225				318/360							
Model	150		200		150		150		200		300/400	
Axle Ratio	3.21		3.54		2.71		2.94		4.10		4.56	
Tire Size	P195/75R15		8.00×16.5-D		P195/75R15		P195/75R15		8.00×16.5-D		8.00×16.5-E	
Throttle Closed	MPH	Km/hr.	MPH	Km/hr.	MPH	Km/hr.	MPH	Km/hr.	MPH	Km/hr.	MPH	Km/hr.
1-2 Upshift	8-11	13-18	8-11	13-18	9-12	14-19	9-11	14-19	7-9	11-14	6-8	10-13
2-3 Upshift	11-14	18-23	11-14	18-23	13-17	21-27	12-15	19-24	9-12	14-19	8-11	13-19
3-1 Downshift ...	8-11	13-18	8-11	13-18	9-12	14-19	9-11	14-19	7-9	11-14	6-8	10-13
Throttle Wide Open												
1-2 Upshift	30-40	48-64	30-40	48-64	36-48	58-77	33-44	53-71	26-35	42-56	23-31	37-50
2-3 Upshift	55-60	89-97	55-60	89-97	65-77	105-124	60-71	97-114	47-56	76-90	42-50	68-80

Used with permission of Chrysler Corporation.

a. In a 1979 D-150 pickup with a 225 CID engine and standard tires and axle ratio, in which speed range (mph) would the transmission downshift from third gear to first gear?

_____

b. You are test driving a 1983 Dodge Ramcharger 200 with a 360 CID engine and standard tires and axle ratio. With the throttle wide open, the transmission upshifts from second gear to third gear at 79 Km/hr. Is this acceptable?

_____

c. A Winnebago camper on a D-150 chassis equipped with a 2.94 axle ratio and a 318 CID engine upshifts from first to second gear at 12 mph with the throttle closed. Is this acceptable?

_____

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2. Table 2 shows fluid capacities for 1980 to 1985 American Motors vehicles. Engine sizes are given as number of cylinders and displacement. Thus, 6-258 means a six-cylinder engine with a 258-cubic-inch displacement.

TABLE 2

CAPACITIES

Year	Engine No. Cyl. Displacement (cu. in.)	Model	Engine Crankcase Add 1 Qt. For New Filter	Transmission (Pts. To Refill After Draining)			Drive Axle (pts)	Cooling System (qts)	
				Manual					
				3-Speed	4-Speed	Automatic		With Heater	With A/C
'80	4-151	Spirit, Concord	3.5⑦	—	3.3	17	3	6.5	6.5
	6-258	Spirit, Concord Pacer, AMX	4	—	3.3	17	3	.11⑧	11⑧
	6-258	Eagle	4	—	3.3⑨	17⑨	3⑩	11	14
'81-'83	4-151	Spirit, Concord	3.0	—	3.5⑨	14.2	3	6.5	6.5
	4-151	Eagle	3.0	—	3.5⑨	14.2	3⑩	6.5	6.5
'81-'85	6-258	Spirit, Concord	4.0	—	3.5⑨	17.0	3	11	14
	6-258	Eagle	4.0	—	3.5⑨	17.0	3⑩	14	14
'84-'85	4-150	Eagle	4.0	—	7.4	15.8	2.5	10.0	10.0

① 2.8—1978
② 3 pts—1978
③ 14.0—1978
④ 18.0—1978
⑤ 16.4—1978
⑥ 8.875 ring gear—4 pts.
⑦ Add ½ qt. for new filter
⑧ 14.5 qts. in Pacer
⑨ Transfer case: 3.0 pts. until March 1980; 4.0 pts. thereafter
⑩ 2.5—front axle
⑪ 82 and later:
T4 Spirit-Concord; 4.0 pts.
T4 Eagle; 3.5 pts.
T5 Spirit-Concord; 4.5 pts.
T5 Eagle; 4.0 pts.
— Not applicable

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

a. You are changing the crankcase oil and oil filter on a 1982 Eagle with a 258 CID engine. How many quarts of oil need to be put into the engine?

_____ Quarts

b. You have just flushed the radiator of a 1980 Pacer equipped with an air conditioner and a 258 CID engine. How much coolant will it take to fill the radiator?

_____ Quarts

c. How much transmission fluid is required to fill the transmission case on a 1984 T5 Concord with a manual transmission and a 258 CID engine?

_____ Pints

d. You are servicing the transfer case on a 1980 Eagle with a 258 CID engine and an automatic transmission. Upon checking the manufacturer's label, you find that the vehicle was manufactured in May of that year. How much fluid will you put in the transfer case?

_____ Pints

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e. How many quarts of coolant are required for a 1985 Eagle with a 150 CID engine equipped with a heater but no air conditioner?

_____ Quarts

3. The table on the opposite page is designed to help service specialists determine the cause of braking problems. It shows symptoms of incorrect brake operation and some possible causes of those symptoms.

a. A customer brings in a 1985 Buick Regal and complains that the brakes squeak whenever she stops. Which of the following are possible causes of the squeak?

_____1) Leaking vacuum system

_____2) Contaminated brake lining

_____3) Weak brake-shoe retention springs

_____4) Improperly adjusted parking brake

b. A customer complains that the brakes on his 1983 Mercury Marquis seem to be slow in releasing. Which of the following is the *most likely* cause of this problem?

_____1) Improper brake fluid

_____2) Glazed brake linings

_____3) Faulty metering valve

_____4) Brake-pedal-linkage interference or binding

c. One of your co-workers attempted to adjust the parking brake on a 1983 Trans Am but did so incorrectly. What is the probable indication of an improperly adjusted parking brake?

_____

d. A customer brings a 1986 Dodge Lancer into your shop and reports that the brake pedal goes almost to the floor before the brakes take hold and that the brake warning light comes on when she applies the brakes. She also thinks that the front brakes may not be working because it seems like the rear brakes do most of the stopping. You ask her whether the excessive pedal travel developed gradually or started all at once. She reports that it has been that way ever since another shop replaced a leaking brake hose. What do you think is the most likely cause?

_____1) Leaking brake line or connection

_____2) Leaking wheel cylinder or piston seal

_____3) Leaking master cylinder

_____4) Air in the brake system

Brake Diagnosis

CAUSE \ SYMPTOM	Excessive Brake Pedal Travel	Brake Pedal Travel Gradually Increases	Excessive Brake Pedal Effort	Brakes Slow to Respond	Brakes Slow to Release	Brakes Drag	Uneven Braking Action (Side to Side)	Uneven Braking Action (Front to Rear)	Scraping Noise from Brakes	Brakes Squeak During Application	Brakes Squeak	Brake Tell-Tale Glows During Stop
Leaking Brake Line or Connection	X	XX						X				XX
Leaking Wheel Cylinder or Piston Seal	X	XX					X					X
Leaking Master Cylinder	X	XX										X
Air in Brake System	XX							X				XX
Contaminated or Improper Brake Fluid				X	X	X						X
Leaking Vacuum System			XX	X								
Restricted Air Passage in Power Head			X	XX	X							
Damaged Power Head			X	X	X	X						
Improperly Assembled Power Head Valving			X	X	X	XX						
Worn Out Brake Lining — Replace			X				X	X	X	X	X	
Uneven Brake Lining Wear — Replace and Correct	X						X	X	X	X	XX	X
Glazed Brake Lining			XX	X			X	X		X	X	
Incorrect Lining Material — Replace			X				X	X			X	
Contaminated Brake Lining — Replace							XX	XX	X	X	X	
Linings Damaged by Abusive Use — Replace			X				X	X	X	X	X	
Excessive Brake Lining Dust			X				XX	XX		X	XX	
Incorrect Wheel Cylinder Sizes			X				X	X				
Weak or Incorrect Brake Shoe Retention Springs					X	XX	X	X	XX	X	XX	
Brake Assembly Attachments — Missing or Loose	X					X	X	X	X		X	
Insufficient Brake Shoe Guide Lubricant					X	X	X	X	XX	XX		
Restricted Brake Fluid Passage or Sticking Wheel Cylinder Piston		X	X	X	X	X	X	X				
Faulty Metering Valve	X		X	X	X	X		X				X
Brake Pedal Linkage Interference or Binding			X	X	XX	XX						
Improperly Adjusted Parking Brake						X						
Improperly Adjusted Master Cylinder Push Rod	X				X	XX						X
Sticking Wheel Cylinder or Caliper Pistons			X		X	X	X	X				
Faulty Proportioning Valve			X	X	X	X						

XX — Indicates more probable cause(s) X — Indicates causes

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ASSIGNMENT SHEET 6

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 8

Use reference materials to answer specific questions

Name _____ Score _____

INTRODUCTION

There is just too much information for the automotive service specialist to memorize. Every vehicle is virtually a unique creation, especially when you consider all the options that are available. As a result, the service specialist must be able to use the various types of references employed in the trade to determine part numbers, procedures, specifications, applications, and other information. To do so means having the ability to locate and interpret information in various books, bulletins, charts, vehicle labels, and elsewhere. Without this ability, the service specialist could perform a procedure incorrectly, and that could damage the vehicle, make it run poorly, or even endanger the lives of those who use the vehicle and share the roadways with it. On the other hand, skill in using reference materials and applying the information contained in them is necessary for a successful career in automotive service.

DIRECTIONS

In this assignment you will be asked questions that will require you to use a variety of automotive service reference materials in order to determine the answers. Many of the questions will have more than one source for the answers, such as a manufacturer's service manual or a professional manual. Other questions will refer to materials provided with this assignment sheet. Read the questions and look up the answers as required. Write the answers in the space provided or write an "X" before the correct answer. For questions where you must check resources not included in this assignment sheet, also list the source of your answer in the space provided.

1. List three oil filters (by brand and model) that can be used on a 1986 Pontiac Fiero with a 2.5-liter engine.

Filter	Source
_____	_____
_____	_____
_____	_____

2. You have just changed the shock absorbers on a 1985 Chevrolet Corvette. The shocks are air-filled. What procedure do you need to follow before disposing of the shocks?

_____

_____

Source — _____

NOTE: Questions 3 through 7 require you to refer to the service bulletin printed on the opposite page.

3. This service bulletin provides information about what type of vehicles?

   _____

4. What problem or subject does this service bulletin address?

   _____

5. What may be the cause of this condition?

   _____

   _____

6. What indicates the need to replace the distributor cap with the new design?

   _____

   _____

7. What is the part number of the distributor cap with the new design for a 4-cylinder engine?

   _____

8. During the late 1970s, Ford manufactured two versions of their 351 CID engine. One was the 351 Windsor and the other was the 351 Modified (Cleveland). How can the service specialist quickly distinguish between these two engines?

   _____

   _____

   Source — _____

9. The VIN on a 1987 Camaro Berlinetta is 1G1FS47G6H319904. What size engine is in this vehicle?

   _____

   Source — _____

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MITCHELL™

TECH SERVICE BULLETIN

NUMBER
2-14

APPLICATION
1983-84 Ford Vehicles

SUBJECT
Rough Running or No Start

SECTION
TUNE-UP & EMISSION: Distributor

CONDITION & CAUSE

Some 1983-84 Ford vehicles may start running rough or may not start. This condition may be caused by moisture trapped in the distributor cap due to a chemical reaction. New design distributor caps are now available to correct this condition.

REPAIR

If distributor cap surface has evidence of moisture, replace the distributor cap with the new design.

Distributor Cap Applications

Engine	Part Number
4-Cylinder	(E5FZ-12106-B)
6-Cylinder	(E2ZZ-12106-A)
V8	(E4TZ-12106-A)

REFERENCE:
Ford Motor Co., Technical Service Bulletin, No. 84-22-3, October, 1984

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NOTE: Questions 10 through 14 require you to refer to the parts and time guide page on the opposite page. Under time, the numbers in parentheses—for example, (0.4)—indicate the time allowance for repairs made under warranty, while the other figure represents the industry standard for performing the task. Under parts, the figure following the part number is the suggested retail price.

10. What is the industry-standard time for replacing the oil filter on a 1982 Concord with a 151 CID engine?

    _____

11. What is the industry-standard time to drain an automatic transmission, change the filter, and refill the transmission with fluid for a 1980 AMX?

    _____

12. Which of the following will be done during factory-standard service of the cooling system?

    _____a. Pressure test for leaks

    _____b. Check operation of thermostat

    _____c. Check ignition and emissions system

    _____d. Flush system and add coolant

13. What is the part number of an exhaust emission anti-backfire valve to be used on a 1980 Eagle with a 258 CID six-cylinder engine equipped with California emission controls?

    _____

14. What is the part number of the oil filter element to be used on a 1979 Spirit equipped with a 121 CID four-cylinder engine?

    _____

15. What is the firing order of the 1.0-liter engine on the 1985 Chevrolet Sprint?

    _____

    Source — _____

16. In 1980 and other early-80s-model Fords, Lincolns, and Mercuries with automatic overdrive transmissions, can the driver place the gear selector in second gear? Why or why not?

    _____

    _____

    Source — _____

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Maintenance & Lubrication (Group 1)—TIME

OPERATION INDEX

Chassis Lubrication *1*
Oil Change *2*
Auto. Trans., Drain & Refill *3*
Front Wheel Bearings, Repack *4*
Air Cleaner, Service Or Renew Element *5*
Oil Filter Element, Renew *6*
Rotate All Wheels *7*
Fuel Filter Element, Renew *8*
Engine Performance Check *9*
Cooling System Service *10*

1—CHASSIS LUBRICATION (C)

Includes: Install & lubricate all fittings. Check & adjust fluid levels in steering gear, front & rear axle, transmission, brake and clutch master cylinder, radiator and battery. Check & adjust tire pressure and clean breather element.

2 WD (0.4) 0.4
4 WD (0.5) 0.5

2—OIL CHANGE (C)

All Models (0.2) 0.2

3—AUTO. TRANS., DRAIN & REFILL (C)

All Models (0.5) 0.6

—NOTE—

To Renew Filter, Add (0.1) *0.1*

4—FRONT WHEEL BEARINGS, REPACK (B)

Drum Brakes (0.5) 0.8
Disc Brakes—
1976-82, Exc (0.9) 1.3
Ser 30-50 (1.8) 2.2

5—AIR CLEANER, SERVICE OR RENEW ELEMENT (C)

All Models (0.2) 0.2

6—OIL FILTER ELEMENT, RENEW (C)

Exc Below (0.3) 0.3
4-151 (0.2) 0.2

7—ROTATE ALL WHEELS (C)

Includes spare.
All Models (0.5) 0.5

8—FUEL FILTER, RENEW (C)

1974-82 (0.2) 0.2

9—ENGINE PERFORMANCE CHECK (B)

Includes: Check ignition & emissions systems.
All Models (0.5) 0.5

10—COOLING SYSTEM SERVICE (C)

Includes: Pressure test system for leaks, check thermostat & heater operation, check all belts, drain & flush system & add coolant.
All Models (0.8) 0.8

Maintenance & Lubrication (Group 1)—PARTS

PARTS INDEX

Oil Filter Element *1*
Air Cleaner Element *2*
Fuel Tank Filter *3*

1—OIL FILTER ELEMENT:

1975-78 Exc	8993146	6.75
Four	8127168	6.75
1979-81 Exc	8993146	6.75
Four, 79	8127168	6.75
80-81	8132313	6.50

2—AIR CLEANER ELEMENT (DRY TYPE):

1975-81 Six & Four	8991386	6.95
1975-79 V8—		
Ser 10&80	8992661	6.60
Ser 01&40	8992873	7.20
Ser 60	8991386	6.95

3—FUEL TANK FILTER

1976	3163974	1.60
1977, 2&3/4"	3163974	1.60
1977-81, 4&3/8"	3230376	1.60

Emission Controls (Group 2)—PARTS

PARTS INDEX

Exhaust Emission Air Pump *1*
Exhaust Emission Anti Back-Fire Valve *3*
Exhaust Emission Pump Belt *4*
Distributor Thermostatic Vacuum Valve (Switch) *5*
Crankcase Vent Valve *6*
Fuel Tank Vent Valve *7*
Fuel Vapor Canister *8*
Fuel Vapor Canister Filter *9*
Air Cleaner Sensor Kit *10*
Air Cleaner Vacuum Motor *11*
Exh Gas Recirc Valve *12*

1—EXHAUST EMISSION AIR PUMP:

1975-76 Exc	3224465	107.32
Ser 10&80 V8	3223124	102.21
1977-78, Exc	3224465	107.32
2 Bar Carb	3233814	107.32
1979 Exc	3233814	107.32
Calif	3224465	107.32
1980-81 Six	8132599	107.32
1981 Four, Exc	3238698	100.85
Air Cond	3240024	

3—EXHAUST EMISSION ANTI BACK-FIRE VALVE:

1974-76 Six	3223634	18.27
1974-76 V8	3223271	18.27
1977-78 Four & Six—		
Exc Below	3223634	18.27
Calif Exc	3230816	26.20
Four Std Trans	3230816	26.20
1977-78 V8 Exc	3223271	18.27
Calif	3230822	27.22
1979 Four, Six—		
Exc Below	3223634	18.27
Six-Std. Trans	3230816	26.20
1979 V8	3230822	27.22
1980 Four	8132346	17.65
Six, Exc	3230816	26.20
Eagle, Exc	3223634	18.27
Calif, Hi-Alt	3230816	26.20
1981	3223634	18.27

4—EXHAUST EMISSION PUMP BELT:

—NOTE—

Order By Complete Model Description.

5—DISTRIBUTOR THERMOSTATIC VACUUM VALVE (SWITCH)

1975-78 Switch	3216448	6.45
1977-79 Valve	3228426	6.87

6—CRANKCASE VENTILATION VALVE:

1974-79 V8	3211538	3.00
1974-76 Six, Exc	3211538	3.00
Zinc Finish	3230351	3.17
1977-79 Four	3230351	3.17
1977 Six	3230351	3.17
1978-79 Six	3232845	3.33
1980 Four	8132309	4.25
Six	3236680	3.33
1981 Six	3240359	3.33

Adapted with permission of The Hearst Corporation, from *Motor Parts and Time Guide 1982.*

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17. What is the spark-plug-gap setting for the following makes and models with the engines specified?

a. 1983 AMC Eagle, 151 CID

_____

Source — _____

b. 1982 Mirada, 318 CID with electronic fuel injection

_____

Source — _____

c. 1984 Ford EXP, 140 CID

_____

Source — _____

d. 1985 Cougar XR7, 200 CID

_____

Source — _____

e. 1985 Buick Regal, 231 CID with multi-point fuel injection

_____

Source — _____

f. 1986 Corvette, 350 CID

_____

Source — _____

18. You are working on a 1985 Pontiac 6000 STE with a 173 CID, V-6 engine. The water pump must be replaced. What precaution must be taken with the timing cover?

_____

_____

Source — _____

19. What is the firing order for the following engines?

a. AMC 150 CID — _____

Source — _____

b. Chrysler 225 CID — _____

Source — _____

c. Chevrolet 6.2-liter diesel — _____

Source — _____

d. Ford 302 CID — _____

Source — _____

e. Porsche 4.7-liter — _____

Source — _____

20. You are servicing a 1985 Plymouth Reliant with a 2.2-liter engine. Indicate below whether or not the radiator cap needs to be removed for each of the procedures listed.

	Cap removed	Cap not removed
a. Check coolant level	_____	_____
b. Add additional coolant	_____	_____
c. Drain coolant	_____	_____

Source — _____

ASSIGNMENT SHEET 7	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 9

Master troubleshooting concepts

Name _____

INTRODUCTION

In order to be effective, a service specialist must be able to quickly and accurately identify the cause of vehicle malfunctions. Rather than seeking such causes through trial-and-error methods, the service specialist uses a systematic approach to problem diagnosis called *troubleshooting*. The principles of troubleshooting are discussed in Student Supplement 6.

Automotive service reference materials often contain troubleshooting charts or flow diagrams. These resources guide the service specialist through a process for locating the source of a problem. Thus, an important skill that the automotive service specialist must develop is the ability to troubleshoot vehicle malfunctions, using either reference material charts or by applying troubleshooting principles.

In this assignment sheet, you will have the opportunity to work through a troubleshooting sequence. This exercise will allow you to apply troubleshooting principles and to learn how to troubleshoot a vehicle that will not start.

DIRECTIONS

This assignment sheet is different from most others because it uses a technique called *programmed text*. Programmed text is an instructional method that guides the student through a lesson by presenting information and then asking questions over the presented material. The student's choice of answers determines what other material must be studied. The biggest advantage of programmed text is that it fits the instruction to the student's individual needs. The biggest drawback to this approach is that it sends the student from page to page. However, some troubleshooting techniques also send the service specialist from page to page. So in this assignment, the page-hopping may not be as much of a problem.

Read the first block of information given on the following page, and then answer the question that follows it. The answer you choose will direct you to another block of information, coded with a letter in the left margin. Continue reading the information blocks, answering questions, and proceeding to the next block until you come to the end of the assignment.

A Several systems are involved in getting a vehicle started. Naturally, one of the more important is the starting system. The battery provides electrical power to the starter when the ignition switch is in the START position. A gear in the starter engages the crankshaft flywheel, causing it to turn so that the pistons move through the internal combustion cycle. So the first source of a failure to start may be the electrical portion of the starting system. If the battery is dead or low on power, the starter cannot be powered. Bad connections, corrosion, or frayed wires may prevent enough electricity from reaching the starter. A failure in the ignition switch, starter relay, or starter solenoid may not allow a complete electrical circuit to the starter. Finally, the starter motor itself may have an internal electrical problem.

Basically, three indications are possible for an electrical problem in the starting system. When the key is turned to start,

- nothing happens,
- the starter turns but without enough speed or power to crank the engine, or
- a clicking sound is heard.

The first possibility (nothing happens) means a dead battery or an incomplete electrical circuit. To determine which is the cause, turn on the headlights. Which problem exists if the headlights do not come on? (Check one of the choices below and then go to the block directed.)

_____ The battery is dead or the battery circuit is defective. Go to block K.

_____ There is an incomplete electrical circuit in the starting system. Go to block D.

B Depending on the starting system design, one of two types of switches is generally used to provide power to the starting motor. The relay switch is usually mounted inside the fender of the vehicle under the hood. When the ignition switch is turned to the START position, the relay switch closes, allowing electricity to flow to the starter motor.

A solenoid is another type of switch, though it serves basically the same function as the starter relay. Solenoids are generally mounted on the starter itself.

Both types of switches rely on electromagnets to close them. Thus, some electricity will be used if the switches close. As a result, the headlights would probably dim some when you try to start the vehicle. Also, you would probably hear one or more clicks as the switch contacts close. Because one of the battery cables normally goes directly to the starter relay or solenoid, the circuit is easy to check. More than likely, if you have a good battery and a good connection to the starter relay or solenoid, you will hear one or more clicks and notice a dimming of the headlights if you try to start the vehicle with the lights on.

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In the case of a weak battery or a partially complete connection, there may be enough power to close the starter switch but not enough to turn the starter motor. If this is the case, the headlights may go out completely when you try to start the vehicle.

Even if the starter itself is defective, power will still be used by the relay or solenoid when you try to start the vehicle. Thus, the headlights should dim.

So your correct choice should have been to suspect a defect in the starter control circuit. The starter relay or solenoid is still a possibility, but not as likely as a defective ignition switch, neutral safety switch, or similar starter control device.

If you do not understand why the problem as described is probably in the starter control circuit outside the starter relay or solenoid, reread this section. For a further explanation of why the problem is most likely elsewhere in the circuit, go to block G.

C Your choice will tell you whether the coil is putting out power. However, you have to be careful not to think that spark is getting to the cylinder just because electricity is coming out the the coil. The problem may still be an ignition problem, and more tests are required to check out the whole system. Although your choice is an acceptable starting point, go to block H to find out why the other choice is better.

D In most vehicles, power to the headlights comes directly from the battery, so turning on the headlights is a good way to check to see whether the battery is putting out power. It is possible that a lack of headlights may result from the headlights being burned out. However, both lights being out at once is not too likely. Besides, the parking lights should still be on. A faulty headlight switch may prevent power from getting to the headlights. Some vehicles have circuit protection devices, such as fuses, circuit breakers, or fusible links, in the headlight system. You will learn more about such devices in the unit C-1 "Apply Related Electricity." Still, when troubleshooting, you should consider how likely possibilities are in producing the results you have. Although a defect in the headlight circuit may leave the vehicle without headlights, it would not interfere with the starting system.

This means that either there are two problems or a battery problem that could cause both sets of indications. Therefore, you should suspect a battery problem. This may include a dead battery, a loose connection, a corroded connection, or similar problem that prevents electricity from flowing through the battery circuit.

The purpose in turning on the headlights was to check another circuit fed by the battery to see whether battery power was available. This test showed that it was not. In this way, you have narrowed down the problem possibilities. It appears that the problem is in the battery circuit. If you do not see why this is probably the case, reread this section or talk to your instructor. If you think the problem is probably in the battery circuit, go to block K.

E Your choice is good in that it does the most in isolating the problem to a single portion of the system. But there are many other things to consider when troubleshooting. To learn more about such other considerations, go to block L.

F Your indication is a hum or whine. Ask yourself what about the starting system would make such a noise. Although it is difficult for you to imagine such a noise while doing this assignment, in reality you would be able to listen to the noise more carefully in the shop. Were you to do so in this case, you would be able to tell that the noise was coming from the starter. The sound would begin when the key is placed in the START position. The whine would result from the pinion gear turning very quickly because it is not engaging the flywheel. Then the noise would fade as the pinion gear slowed down.

But what kind of noise would you expect to hear if the pinion gear and flywheel are binding? It would be the sound of metal grinding against metal. In some cases—if the two parts were in a tight bind—you might hear a slight hum as the armature inside the starter tried to turn. However, it is more likely that the gear teeth would grind against each other.

A bent armature would also produce internal starter noise such as a grinding or clunking noise. However, the shaft would have to bend severely to produce such a noise and more than likely would not turn. If it were bent less severely and everything else was all right, the engine would probably crank.

If the starter was not making electrical contacts internally, there would probably be no sound, except the clicking of the starter relay or solenoid.

The most likely cause of a whining noise is the spinning of the armature without engaging the flywheel. Go to block J for further explanation of this problem.

G When the headlights are on without the vehicle running, they draw power steadily from the battery. If you then start the engine, some of the battery power is switched to the starting motor. When this happens, less power goes to the headlights, which means that they cannot shine as brightly. Because the headlights did not dim when you tried to start the vehicle with the headlights on, no power went to the starting motor. So your conclusion that a problem exists in a part of the circuit other than the starter or the solenoid or relay was correct.

If you have made sure that the vehicle is properly set up to start, then part of the starter control circuit must be defective. At this point, the service manual might specify tests designed to narrow the probable causes further.

Let's look at another vehicle with a different problem. When you try to start this vehicle, you hear a noise, but the engine does not crank. Three types of noise are likely with a starting system problem. They are

- a click or series of clicks,
- a grinding noise, or

- a hum or whine.

Each sound indicates different possible problems, so you should listen carefully when troubleshooting a no-start condition. The clicks are made by the closing of the contacts in the starter relay or solenoid. Often a weak battery or bad connection will produce a series of clicks, while a defective starter switch or starter will make a single click.

Grinding noises are signs of a mechanical problem. The teeth of the flywheel or the pinion gear may not be meshing correctly. Parts in the starter may be loose, broken, or improperly installed. There may even be a mechanical problem with the engine.

A hum or whine means that the starter motor is turning, but it is not engaging the flywheel. Which of the following would be the most likely possible causes of such a noise?

_____ The pinion gear and flywheel are binding, the armature shaft in the starter is bent, or the electrical parts inside the starter are not making connection. Go to block F.

_____ The starter is loose on its mountings, teeth on the flywheel are missing, or the starter is not turning fast enough to drive the pinion gear into contact with the flywheel. Go to block J.

H

Actually either method is acceptable, but a couple of things makes one choice better. Your first goal is to determine whether the ignition system is delivering spark. The best way to check out the whole system is to check it near its final point of operation—in this case, at the spark plug. While it's true that the actual point of spark delivery is at the tip of the spark plug, removing the spark plug is much more difficult than simply pulling the wire from one. Besides, the only difference between checking for spark at one end or the other of the spark plug is whether the spark plug itself is defective. Although it is possible to have a defective spark plug, this is not a probable cause of an engine failing to start, especially if everything else is okay.

Similarly, failure to get spark from one spark plug wire may be due to a faulty wire or a flaw in just one part of the distributor. Again, however, poor ignition in one cylinder is not likely to keep the engine from starting. But checking spark at the end of a spark plug wire does check out the whole ignition system. If you have spark then the system is probably working. You have eliminated one possible cause of the problem and can continue your troubleshooting in some other systems.

For this exercise we have assumed that the test procedure is acceptable. However, on an actual vehicle you will want to check with the manufacturer's procedures. Some manufacturers specify use of a spark testing device. Others recommend the use of insulated pliers to hold the spark plug wire. Manufacturers may specify other steps in the procedure, such as isolating electronic equipment or shutting off the fuel supply. These guidelines should, of course, be followed.

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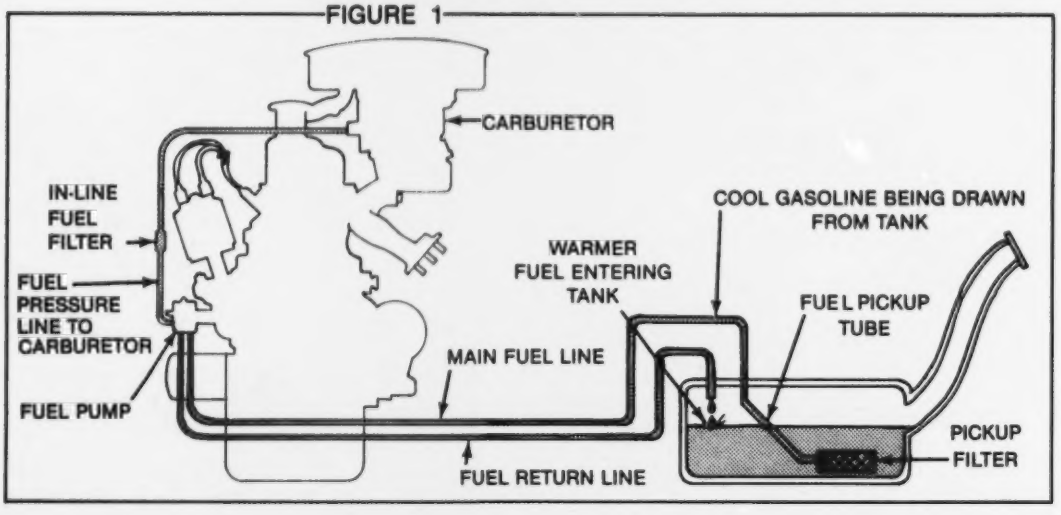
Let's assume that there is no spark at the end of the spark plug wire. Your next step is to isolate the component in the system that is leading to the failure. Naturally you have already checked the connections for fit and visually inspected the wire. Your next step is to isolate and check the separate components. The coil can be checked in the same way the spark plug was checked, by testing for spark in the wire between the coil and the distributor. If you have no spark from the coil, it is a likely candidate. If you have a spark at the coil but none at the spark plug, the distributor is a probable cause. Additionally, components of an electronic ignition control system may cause the problem. Your exact procedure in testing the rest of the system will depend on the vehicle and the manufacturer's recommendations.

If the vehicle has spark, you may choose to check the fuel delivery system next. Again, remember, one of the key principles in troubleshooting is to check the status of the vehicle in relation to what it is that you expect it to do. Naturally, a vehicle needs fuel to start, and you will want to check the fuel gauge immediately if an engine cranks but fails to start. Fuel gauges are not always accurate but if the gauge reads EMPTY, you may have found the problem.

To check for delivery of fuel, you'll want to check as close to the final delivery point as is possible and practical. This will depend on the vehicle. For our example, we'll consider a carbureted gasoline engine. Engines using other fuels or fuel injection systems would be handled differently.

For a carbureted gasoline engine, the easiest way to check for fuel delivery usually is to remove the air filter assembly and check for gasoline in the carburetor. Generally, you can smell the fuel or can see a mist whenever the the throttle is pumped. If you find no gasoline getting to the carburetor, which source would you check next if the fuel system were configured as shown in Figure 1 below?

FIGURE 1



_____ The fuel pressure line between the in-line fuel filter and the carburetor. Go to block L.

_____ The main fuel line where it goes into the fuel pump. Go to block E.

I Your choice would certainly show you whether or not the camshaft were turning. However, to remove the valve cover, you would have to first remove several bolts and perhaps some other parts. When reinstalling the valve cover, you would have to replace the valve cover gasket or sealant. These steps would cost you time and money. Remember that part of the purpose behind systematic troubleshooting is to save you time and money. Do not make hasty decisions that forfeit that benefit. Now go to block M to find out more about checking for a defective timing belt.

J You are probably beginning to see how important it is to understand component operation when troubleshooting. Even though you have not studied the starting system in detail, you have made the right choice. If the starter hums or whines when you try starting a vehicle, the noise is most likely produced by the armature spinning inside the starter. However, for the engine to crank, the pinion gear has to engage the flywheel. Reasons for this not happening include:

- the pinion gear being misaligned with the flywheel as it might be if the starter were loose,
- there being nothing for the pinion gear to engage as would be the case if the flywheel had missing gear teeth where the pinion tried to engage, and
- the starter motor being worn or electrically weak so that it does not drive the pinion gear into the flywheel.

A visual inspection will probably tell you whether the starter is loose or misaligned or if there are teeth missing in the flywheel. Internal problems can only be found by removing the starter and testing it. Remember, one of the principles behind good troubleshooting practices is that you should do the easier of the tests if two possibilities seem just as likely.

When you try starting a vehicle, three things are likely to happen in terms of the starter. We have already discussed two cases—the first where nothing happens and the second where some noise is produced. The third possibility is that the starter works fine. It engages the flywheel and cranks the engine with enough power to begin the reciprocation process, but the engine never fires. This indication points to something other than the battery or the starting circuit.

If you think about the operation of the internal combustion engine, you will realize that there are three keys to proper operation:

1. Fuel must get to the engine in a combustible mixture with air, and the mixture must be compressed.

2. A spark must ignite the compressed fuel-air mixture.

3. The mechanical operation of the engine must be timed in such a way that fuel and spark are delivered when they will be effective.

Thus, the most likely failures when an engine cranks but will not start occur in fuel delivery, ignition, and timing. Let's consider ignition first.

The coil provides electrical power, while the distributor sends that power to the cylinders, one at a time, in a specific order. Ignition takes place when a spark jumps across the gap at the spark plug terminal. The first thing to determine in troubleshooting the ignition system is whether there is spark. Keeping the principles of troubleshooting in mind, which procedure should you perform to check for spark? In answering the question, assume that either procedure is acceptable to the vehicle manufacturer.

_____ Remove a spark plug wire from a spark plug, insert a screwdriver blade into the terminal of the wire, hold the screwdriver so that the blade is near a good ground, crank the engine, and check for spark. Go to block H.

_____ Disconnect the wire between the coil and the distributor at the distributor, insert a screwdriver blade into the terminal of the wire, hold the screwdriver so that the blade is near a good ground, crank the engine, and check for spark. Go to block C.

K You're right. Neither the starter nor the headlights are getting power. A problem in the starting system electrical circuit would not have affected the headlights. The most likely possibilities are that the battery is run down or that there is a bad connection in one of three places:

- the battery positive terminal,
- the battery negative terminal, or
- the connection between the battery and the engine.

The bad connection may be the result of corrosion (chemical buildup) or simply a loose connection. The electrical circuit problem may also be caused by a faulty battery cable, such as one that is broken or corroded. You will be able to detect most of these conditions through a visual inspection. If the problem is the battery, charging or replacing the battery may solve the failure to start.

But let's suppose that when you try starting the vehicle, nothing happens. So you turn on the headlights and they come on. In this case, the problem must be in the starting system electrical circuit. The starting system electrical circuit consists of the cable from the battery, the START position on the ignition switch, a solenoid or relay, the electromagnetic components of the starter motor, and the connections between these parts. Defects, loose connections, or corrosion in this circuit can prevent electricity from reaching the starter.

But vehicle manufacturers often add safety devices to the starter control circuit. These devices are generally switches that prevent completion of the electrical circuit if starting the vehicle could be dangerous. For example, vehicles with automatic transmissions generally have devices called *neutral safety switches*. The neutral safety switch does not allow completion of the starter control circuit unless the transmission is in PARK or NEUTRAL.

A vehicle which starts with the transmission gears engaged could run into someone or something before the driver has time to react. Vehicles with manual transmissions often have a similar device called a *clutch start switch* that prevents starting unless the clutch pedal is depressed or the transmission is in neutral. Another safety device is the *seat belt interlock* switch which prevents starting unless the driver's seat belt is fastened.

As with any troubleshooting procedure, check for operator errors and obvious mistakes first. It can be very embarrassing to go through a complicated troubleshooting procedure only to find out later that the transmission is in DRIVE. Remember, one of the key steps in troubleshooting is to compare system operation to how the system is supposed to be operating for the conditions.

So, let's say the transmission is in PARK and the driver's seat belt is fastened. The next troubleshooting step is to try starting the vehicle with the headlights on. One of two things is likely to happen. The headlights may dim or they may not change in brightness, depending on where the electrical problem is in the circuit. Which problem is more likely if the lights do not change in brightness?

_____ A problem in the solenoid or relay or in the starter. Go to block B.

_____ A problem in some other part of the circuit, such as the ignition switch, neutral safety switch, or seat belt interlock switch. Go to block G.

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L

Actually, you have three good troubleshooting choices in this situation you could also check the fuel line between the pump and the in-line filter. Each check point would give you slightly different information. If there were no fuel coming from the main fuel line between the fuel pump and tank, the most likely problem would be a clogged main fuel line or pickup filter. If no fuel were coming from the fuel pressure line between the filter and the carburetor, the problem could be a clogged line anywhere in the system, a clogged in-line filter, a defective fuel pump, or a clogged pickup filter.

Thus, in terms of isolating the problem, your best choice is to check for fuel coming into the fuel pump. However, a number of other considerations should also be weighed. For example, how hard is it to get to the fuel pump main line? How old is the vehicle and the parts in use in the fuel delivery system? Has the vehicle shown any other signs before this problem, such as sputtering at low speeds or engine miss at high speeds? All these factors and others might influence your decision in the troubleshooting sequence.

You must remember that the purpose of troubleshooting principles is to give you a systematic approach to figuring out problems. But each vehicle and each situation is unique. As you diagnose a problem, you must analyze your actions and the indications each step of the way. Such analysis is the only way you can correctly determine the proper course of action.

For example, suppose that on this vehicle the in-line fuel filter is easy to reach, while the fuel pump is difficult to get to. The vehicle has several thousand miles on it, and the original fuel filter is still being used. You have a replacement filter in your shop. You may choose to check for fuel coming out of the in-line filter during your troubleshooting procedure. If you find that there is no fuel getting past the filter, you may decide to substitute the replacement filter and check for fuel once more. If fuel is then getting past the filter, you've probably solved the problem. If not, then you have eliminated the filter as the source of the problem and can then check other components that are more difficult to reach.

Substituting a known good part for one that is suspected to be defective is a common practice in troubleshooting. You do not want to substitute parts without first understanding what you will find out by doing so, but in many cases, part substitution can be a very informative troubleshooting practice.

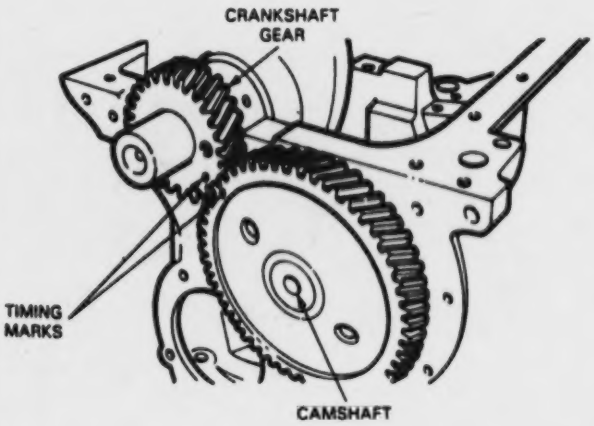
Another fuel problem that can prevent a vehicle from starting is the incorrect amount of fuel. Although this may mean that not enough fuel is getting to the cylinders—such as with low fuel level in the carburetor bowl or a restricted fuel delivery system or a leak in the intake manifold—a more common fuel quantity problem is too much fuel. This condition is called *flooding* and is often caused by incorrect starting procedures. For example, a driver may pump the throttle pedal several times, dumping an excessive amount of gasoline into the carburetor so that a proper fuel-air mixture cannot be achieved. Vehicle manufacturers provide starting instructions in their owner's manuals.

The third factor required for proper operation of the internal combustion engine—in addition to spark and fuel—is correct timing of the mechanical operation of the engine. In other words, the valves must open and close at the right time and the piston must be in the correct position for that instant when spark is delivered to the piston. Every part can be operating perfectly, but if they are not in time with each other combustion will not take place—at least not well enough to provide good power.

The camshaft, which controls opening and closing of the valves, and the crankshaft, which moves the pistons up and down, are mechanically connected to each other. The means of connection varies with engine designs, but the three most common methods are

- direct meshing gears,
- chain-connected gears, and
- belt-connected gears.

FIGURE 2



The gears on the end of the crankshaft and camshaft have marks on them called *timing marks* (Figure 2). When these marks are aligned correctly with each other, the valves and pistons are in proper synchronization. This timing is set at the factory or whenever the engine is overhauled.

Used with permission of General Motors Corporation, Pontiac Motor Division.

But sometimes defects occur in the mechanical linkage. Teeth on a gear may break or become worn. A belt or chain may break or slip. Teeth on a belt may strip off. These problems may prevent the camshaft from turning even though the starting motor is turning the crankshaft by rotating the flywheel. Or, if the camshaft and crankshaft are not properly aligned with each other, combustion will not occur when it should, and the engine will fail to start or will run poorly.

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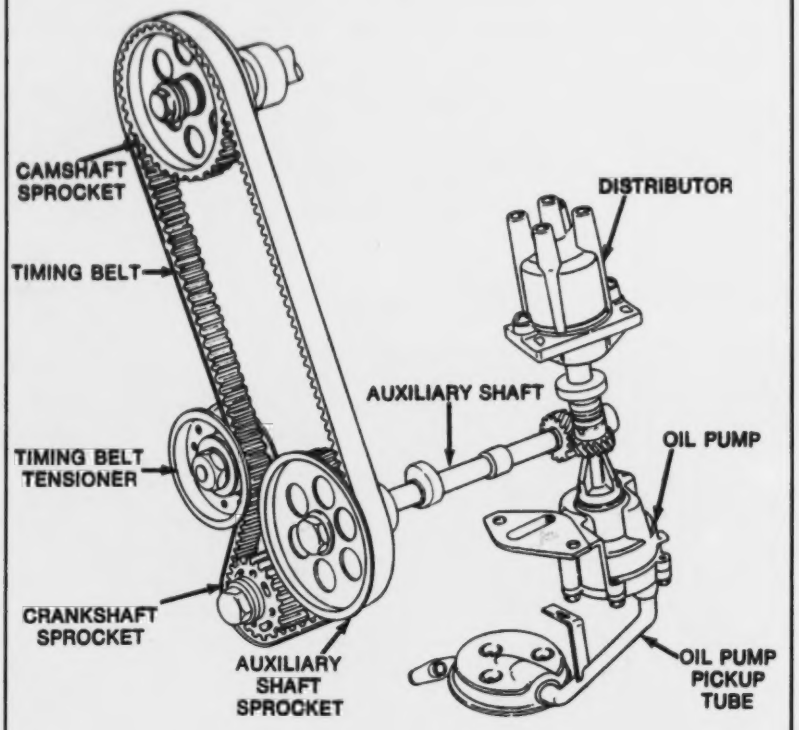
Remember, though, even if the camshaft and crankshaft are timed with each other, a vehicle may still have a timing problem. Why? Because the spark must be delivered to a particular cylinder after the fuel-air mixture has been delivered to that cylinder and compressed. Spark delivery is controlled by the distributor. For this reason, the distributor is also mechanically linked to the crankshaft-camshaft drive mechanism. Generally, this is done through the use of shafts and gears as shown in Figure 3 below. Naturally, defects may occur in these shafts and gears.

FIGURE 3



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

Suppose that you are working on a vehicle that will not start. It has a timing mechanism similar to the one shown above with the timing belt behind a cover. You suspect that the timing belt has broken or that some teeth are missing so that it does not turn. Which of the following would be a good way to check to see whether the belt moves when the starter cranks the engine?

_____ Remove the valve cover to see whether the camshaft is turning. Go to block I.

_____ Remove the distributor cap to see whether the rotor is turning. Go to block M.

M

Because the timing belt also drives the auxiliary shaft which in turn rotates the distributor shaft, you can get a good idea about whether the timing belt is moving by checking to see whether the distributor rotor is turning. Notice that in the design shown and in many others, the oil pump is also driven by the auxiliary shaft. The cam on the auxiliary shaft in this design also operates the fuel pump. Thus, if the timing belt, chain, or gears no longer turn, the vehicle will have neither spark nor fuel.

Most distributor caps are fairly easy to remove, while timing belts, chains, and gears are not always easy to get to. Even those that are easy to reach may be hidden behind covers that are difficult to remove. Some timing device covers are equipped with plugs that are easy to remove so that the service person can see the timing device.

Be careful not to be misled because the crankshaft is turning and belts are moving, such as those for the water pump, power steering pump, air conditioner, and alternator. Those components have nothing to do with the timing belt. They are driven by a pulley attached to the crankshaft gear. As long as the starting motor can turn the crankshaft, those belts will move.

This exercise has given you a chance to think about troubleshooting principles. Now that you have been through it once, you should go through it a second time to review what you have learned. Practice in applying diagnostic skills is just as important as practice in using tools or reference materials.

For this exercise, we concentrated on troubleshooting a vehicle that would not start. However, the concepts you have studied in this assignment and in Student Supplement 6 apply to other aspects of vehicle operation. Service personnel must troubleshoot brake problems, transmission problems, faulty heating and air conditioning systems, electrical problems, suspension and steering defects, and any other conditions in which a vehicle does not work as it should. The principles you have learned here can be used throughout your career.

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ASSIGNMENT ANSWERS	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

ASSIGNMENT SHEET 1

1. a. St. Louis
   b. 2.5L
   c. 32
   d. 9.0; 8.5
   e. Removal of the front wheels

2. a. 4.3L V6
   b. 5001-6000
   c. 5; 4.8
   d. 1-6-5-4-3-2
   e. J23590

3. a. The pan has two drain plugs—both must be opened
   b. 1-3-7-2-6-5-4-8
   c. 20
   d. 2
   e. Left side

ASSIGNMENT SHEET 2

1. a. Left
   b. 1)
   c. 1)

2. a. Ring, pin, two locks, piston, rod, cap, and two bolts
   b. 4)
   c. 1)

3. a. Bearing housing
   b. 4)
   c. Turn signal and flasher switch

4. a. 1), 4)
   b. Yellow; 4
   c. .2435

5. a. Black
   b. Red-dashed
   c. White
   d. Red-solid
   e. TIDC valve

ASSIGNMENT SHEET 3

1. a. Decrease
   b. Horizontal
   c. Degrees Fahrenheit
   d. 70 percent

2. a. Service life decreases
   b. 10,000 miles
   c. 65 percent

3. a. Higher
   b. Cylinder 2
   c. That cylinders 2 and 5 each have richer mixtures than those on either side of them

4. a. The drop in the torque curve at approximately 1700 rpm
   b. Increases
   c. 1) 42-44
      2) 82-86
      3) 121-124
      4) 127-129

ASSIGNMENT SHEET 4

1. a. Orange/light blue
   b. White-black stripe
   c. Yellow-white dot
   d. Black-orange
   e. Green-red stripe

2. a. Atmospheric pressure
   b. Exhaust manifold
   c. Pressurized charge air
   d. Pressurized and recooled charge air

3. a. Wheels, bearings, tires
   b. 2)
   c. Have co-worker limit wheel spin to 35 mph; failure to do so could result in tire disintegration or differential failure
   d. Replace hub and bearing assembly

ASSIGNMENT SHEET 5

1. a. 8 to 11 mph
   b. Yes
   c. No

2. a. 5
   b. 14.5
   c. 4.5
   d. 4
   e. 10

3. a. 2), 3)
   b. 4)
   c. Dragging brakes
   d. 4)

ASSIGNMENT SHEET 6

NOTE: There are several possible sources where answers may be obtained.

1. Several answers possible
2. The air needs to be relieved by drilling a hole into the cylinder
3. 1983-84 Ford vehicles
4. Rough running or no start
5. Moisture trapped in the distributor cap due to a chemical condition
6. If the distributor cap surface has evidence of moisture
7. E5FZ-12106-B
8. Windsor engines have thermostat housing mounted on front of intake manifold, modified engines have thermostat mounted on block (other answers are possible)
9. 305 CID (5.0L)
10. 0.2
11. 0.7
12. a, b, d
13. 3230816
14. 8127168
15. 1-3-2
16. No; there is no second-gear position
17. a. .060
    b. .048
    c. .044
    d. .050
    e. .045
    f. .045
18. Install special tool J29176 to clamp timing cover to block prior to removing water-pump bolts

19. a. 4-3-2-1
    b. 1-5-3-6-2-4
    c. 1-8-7-2-6-5-4-3
    d. 1-5-4-2-6-3-7-8
    e. 1-3-7-2-6-5-4-8

20. a. Cap not removed
    b. Cap not removed
    c. Cap not removed

ASSIGNMENT SHEET 7

NOTE: Correct responses for this assignment sheet are not listed. One of the two choices in each block is a more logical choice and will direct the student to the next appropriate block; however the other choice further explains the situation and will also lead the student to the appropriate block.

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

ACTIVITY SHEET 1

Report on service bulletins

Name _____

INTRODUCTION

One important reference in the automotive service industry is the service bulletin. Service bulletins are published by vehicle manufacturers, equipment and parts manufacturers, and automotive information service companies, such as professional manual publishers. The bulletins may be issued on a regular basis or as needed to inform technicians of the latest procedures and service information. These updates are necessary for various reasons, such as to inform technicians of design changes made in a vehicle during the course of a model year, to warn them of common service problems or mistakes, to outline new service procedures, to correct published service procedure or specification errors, and other reasons. The bulletins are often accompanied by an index which lists the bulletins by make and model of vehicle, systems affected, and specific problem. It is important that service technicians be able to locate the bulletins that apply to their work and be able to understand the information contained in the bulletins.

DIRECTIONS

Your instructor will assign you a service bulletin concerning a make or family of vehicles or a particular design of systems or will assign you a series of service bulletins for you to report on. The report may be written or presented orally to the class as specified by your instructor.

JOB SHEET 1

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 10

Replace fuses

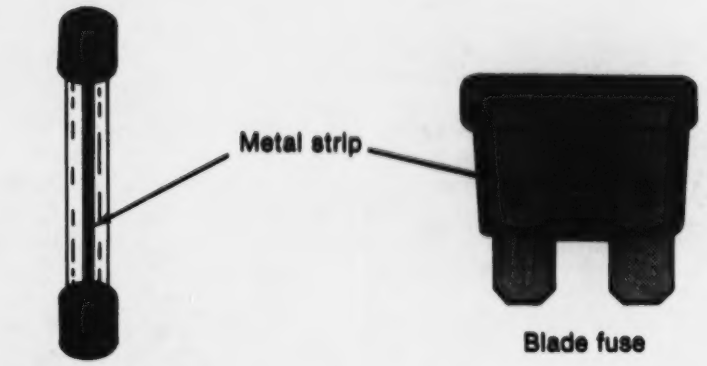
INTRODUCTION

Most vehicles are equipped with devices called *fuses* to protect the electrical system and its components. You will learn more about fuses when you study electrical and electronic systems, but replacing fuses is a good activity to help you become familiar with using reference materials.

Fuses are generally located in a compartment under the dash near the steering column. This compartment is called a fuse block or box. However, a specific vehicle may have more than one fuse block or may have individual fuses that are located elsewhere, such with the equipment the fuse protects.

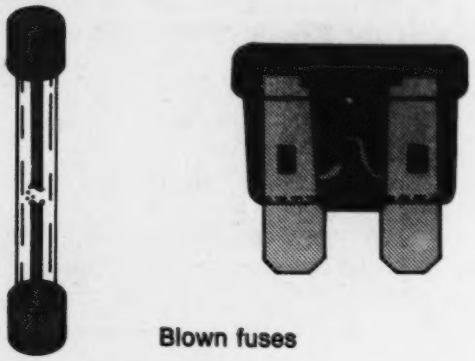
Fuses protect equipment by interrupting the flow of electricity to a component when too much electricity is going through the circuit. Automotive fuses come in two general designs—a cartridge-type and a blade-type (see Figure 1).

FIGURE 1



Fuses contain a metal strip or wire through which the electrical current flows. If the current is too high, the wire or metal strip melts, thus stopping the flow of electricity in that circuit. When this happens, the fuse is said to be *blown* (see Figure 2). Checking a fuse visually is usually all that needs to be done to see if a fuse has blown. Although a fuse may occasionally blow because of age or other defect or because of some passing problem in the electrical system, a blown fuse should be considered an indication of a problem in the circuit, and repairs may be required in addition to replacing the fuse.

FIGURE 2



Blown fuses

Fuses are made to blow at various levels of electrical flow, depending on the normal electrical level in that circuit. Electrical current is measured in *amperes* or *amps*, and fuses are classed by the number of amperes they can conduct without blowing. Thus, one circuit may have a 10-amp fuse while another may have a 35-amp fuse.

To properly operate and protect a circuit, the correct size of fuse must be used. If a fuse with too small of a rating is used, it will blow without the component getting enough electricity to operate. If a fuse with too high of a rating is used, too much electricity may flow to the component and damage it. The correct size of fuse required can be determined by checking the vehicle owner's manual or service manual. These references will also give the location of the fuse block and tell what equipment is served by each fuse.

EQUIPMENT AND MATERIALS

- Vehicle
- Vehicle owner's manual
- Fuses
- Hand tools as required to gain access to fuse block

PROCEDURE

1. Refer to owner's manual to determine location of fuse block and fuse application
2. Remove watches, rings, and jewelry
3. Remove fuse block access cover, and locate fuse for affected circuit
4. Remove fuse

   CAUTION

   Use care when removing fuse to avoid breaking fuse or damaging fuse block. Work fuse from retainer carefully and slowly. Avoid using pliers, screwdrivers, or other metal objects to remove fuses because they may contact hot circuits that could lead to equipment damage.

5. Inspect or test fuse; replace if necessary

   NOTE: Even though a fuse looks good, it still may be bad. Only by testing can you be sure the fuse is good or bad. Inspecting and testing a fuse may be done as part of an electrical troubleshooting procedure. If a fuse is blown, repairs to the circuit may be required. These should be completed prior to installing a new fuse.

6. Install good fuse, making sure that ends of cartridge or blades make good contact in receptacle
7. Reinstall fuse block access cover
8. Clean work area and put away tools and equipment

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JOB SHEET 2

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 11

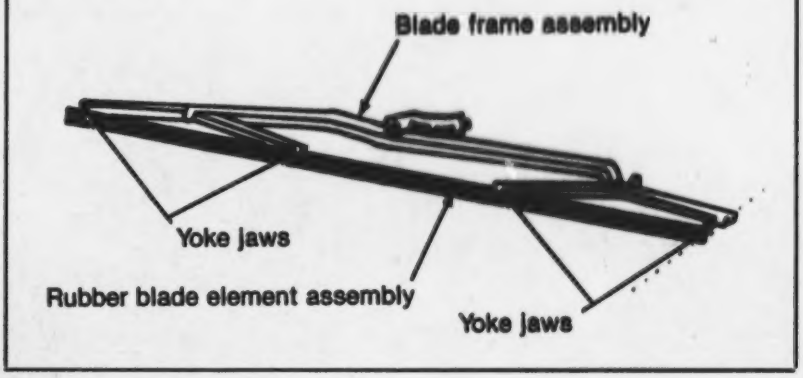
Replace wiper blades

INTRODUCTION

Front and rear window wipers are important automotive safety equipment. But to do an effective job of clearing away moisture, a wiper must be equipped with a good blade that contacts the glass evenly, moves across it easily, and removes the moisture thoroughly. Two nonelectrical problems may lead to a wiper failing to operate properly: 1) The blade may be worn, hardened, improperly installed, or otherwise defective, or 2) the wiper arm may be loose, bent, worn, improperly installed, or otherwise defective. The blade and arm should be checked periodically, and most states include examination of the wipers as part of their safety inspection requirements.

Indications of a problem in the blade or wiper arm may include streaks or scratches on the windshield, unusual noises, areas of poor moisture removal, wipers stuck at some point in their travel, or side-to-side movement of the blade during operation as well as visual signs such as cracks, separation, breaks, tears, and bends. When inspecting the wiper blade and arm, first lift the arm away from the glass and visually check the blade for signs of defects. Gently pull the blade away from the frame assembly (see Figure 1) to check for separation and to check to see that it is securely fitted in the holding jaws. Check for proper tension in the wiper arm by pulling the blade frame assembly out from the glass about four

FIGURE 1



Used with permission of The Hearst Corporation, from *Basic Car Care Illustrated*, 2nd ed., ©1980.

inches and releasing it. The arm should spring back against the glass, indicating that there is enough tension in the arm to hold the blade against the glass to effectively remove moisture. If the arm does not snap back, the spring in the arm is probably broken, in which case the spring or the arm may have to be replaced.

You may have to use several references in order to correctly replace a wiper blade element. First, you must determine the correct blade length and design for the make and model of vehicle being serviced. This is done by referring to a wiper blade manufacturer's catalog or a parts interchange manual. Some service manuals may also include this information.

Second, you must refer to the correct service manual for detailed instructions on the replacement procedure. There are many designs used to hold the blade element to the frame assembly, most of which are not obvious in operation to someone just looking at the wiper. Some designs allow blade replacement without the use of any tools, while others require the use of a screwdriver or small drill bit or pin to trip a release mechanism. It is important to follow the procedures exactly so that the wiper assembly is not damaged beyond repair. Fortunately, once the service technician has learned a few basic approaches, he or she will be able to replace wiper blades on most vehicles.

EQUIPMENT AND MATERIALS

- Vehicle
- Parts guide to determine correct replacement blade
- Appropriate service manual
- Tools required for procedure
- Replacement blade elements

NOTE: For practice, you may remove wiper blades and then reinstall them if they are in good condition.

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped.

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JOB SHEET 3	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 12

Troubleshoot a vehicle that will not start

INTRODUCTION

In Student Supplement 6, you learned the basic steps in a systematic troubleshooting procedure. Assignment Sheet 7 gave you a chance to apply those principles while learning about troubleshooting a vehicle that will not start. In this job sheet you will practice troubleshooting techniques on specific vehicles. You will not be expected to make the repairs, but you should be able to identify the part or parts that are malfunctioning.

Because each vehicle is unique, the exact troubleshooting steps will vary from vehicle to vehicle and will depend on the equipment used in each individual case. For example, the steps for checking for fuel delivery in a carbureted fuel system will be different from those used for a system with fuel injectors. When diagnosing the problem, you may be able to use the general principles of troubleshooting to narrow the probable cause to the fuel delivery system. At that point you would have to refer to the service manual for specific instructions in disconnecting a fuel hose or relieving pressure in a fuel injection system.

Even when following a flow diagram or other troubleshooting instructions in a service manual, the service specialist must be careful to observe normal safety precautions and to use sound judgment and work practices. Troubleshooting charts are mostly convenient, quick references and do not detail everything that the service specialist must do.

As you continue your career in automotive service you will study many other diagnostic techniques for a variety of problems in many different vehicle systems. However, each will follow the principles you have studied and that you will apply in this procedure.

EQUIPMENT AND MATERIALS

- One or more vehicles that will not start
- Service manual(s) for the vehicle(s)
- Basic hand tool set
- Student Supplement 6
- Assignment Sheet 7

PROCEDURE

NOTE: Use your student materials and the service manual(s) to determine the steps required to isolate the problem.

PRACTICAL TEST

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

JOB SHEET 1

Replace fuses

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Located fuse block.	_____	_____
3. Used reference materials to determine correct replacement fuse(s).	_____	_____
4. Replaced fuse(s) following outlined procedure.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

JOB SHEET 2

Replace wiper blades

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used reference materials to determine correct blade length and design.	_____	_____
3. Replaced blade(s) following procedure outlined in service manual.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

JOB SHEET 3

Troubleshoot a vehicle that will not start

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Verified problem.	_____	_____
3. Used reference materials correctly to isolate problem.	_____	_____
4. Performed necessary tests and inspections to isolate problem.	_____	_____
5. Observed safety rules and precautions.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST

USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

Name _____ Score _____

OBJECTIVE 1

Choose the definition that best defines each term. Write the correct numbers in the blanks.

_____a. **Reference materials**

1. Books, pamphlets, charts, and other materials used by automotive service technicians as sources of information in servicing vehicles
2. Tools and devices marked in graduations to permit the measuring of automotive parts
3. Test materials used to check part measurements and dimensions
4. Substance used to mark reference points on vehicle parts

_____b. **Illustrations**

1. Drawings that use symbols to show the relationship between parts or the movement of substances
2. Listings of numbers to allow easy use by the service specialist
3. Advertisements used to promote vehicles to the public
4. Drawings, photographs, diagrams, and other graphics used to clarify information contained in reference materials

_____c. **Specifications**

1. Vehicle features other than those included in the basic design package; usually available at additional cost
2. Quantities of fluids and lubricants used in a vehicle
3. Measurements and features that apply to a specific make and model of vehicle as that vehicle is equipped
4. Amounts of force required to fully tighten certain automotive fasteners

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_____d. **Make of vehicle**

1. Manufacturer's designation of year for a vehicle
2. Designation of a vehicle to show its country of origin
3. Identification of a vehicle according to its manufacturer, name, and special designations
4. Identification of a vehicle by its design and body style, such as a four-door hardtop or station wagon

_____e. **Model of vehicle**

1. Manufacturer's designation of year for a vehicle
2. Designation of a vehicle to show its country of origin
3. Identification of a vehicle according to its manufacturer, name, and special designations
4. Identification of a vehicle by its design and body style, such as a four-door hardtop or station wagon

_____f. **Family of vehicles**

1. Designation of a vehicle by the division of the major company, such as Pontiac Division of General Motors Corporation
2. Makes of vehicles related to each other because of design similarities
3. Makes of vehicles related to each other because of year of manufacture
4. All the vehicle models that have the same basic name, though different options

_____g. **Option**

1. Vehicle feature other than those included in basic design package; usually available at additional cost
2. Rating system for gasoline
3. Portion of a reference or other book in which topics covered in the book are listed in alphabetical order with page numbers
4. Flow diagram in which the operation of a vehicle system is described

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_____h. **Domestic vehicle**

1. One that is primarily manufactured and assembled in a person's home country
2. One that is primarily manufactured and assembled in a country other than a person's home country
3. One intended primarily for private use, to carry passengers
4. One intended primarily for commercial use, to carry loads

_____i. **Imported vehicle**

1. One that is primarily manufactured and assembled in a person's home country
2. One that is primarily manufactured and assembled in a country other than a person's home country
3. One intended primarily for private use, to carry passengers
4. One intended primarily for commercial use, to carry loads

OBJECTIVE 2

Read the following situations. Write an "X" beside each type of reference material listed with the situation that could be used to provide the information required by that situation.

a. The part manufacturer's number for an oil filter to replace the original equipment

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Parts guide

_____4. Interchange manual

b. Engine firing order for a particular engine

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Service bulletin

_____4. Specialty manual

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c. The time required to change a water pump on a vehicle

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Flat-rate manual

_____4. Specialty manual

d. Chart showing when normal maintenance should be performed on a vehicle

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Owner's manual for that vehicle

_____4. Flat-rate manual

e. Detailed instructions only on the operation and service of automatic transmission for a variety of vehicles

_____1. Service manual

_____2. Professional manual

_____3. Service bulletin

_____4. Specialty manual

f. The suggested retail price for vehicle parts

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Parts guide

_____4. Interchange manual

g. A report updating service specialists on a change in a service procedure

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Service bulletin

_____4. Specialty manual

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h. Step-by-step procedure on how to replace the fuel pump on a vehicle

_____1. Service manual for that vehicle

_____2. Professional manual

_____3. Flat-rate manual

_____4. Interchange manual

OBJECTIVE 3

Use the vehicle identification number (VIN) chart on the opposite page and a service or professional manual to answer the following questions. Write your answers in the spaces provided.

NOTE: For these questions, the vehicle being considered has a VIN of

1G1JE87P6H6337184

a. What make and model of vehicle is this?

_____

b. What size and type of engine does this vehicle have?

_____

c. What is the body style of this vehicle?

_____

d. In what plant was this vehicle assembled?

_____

e. What is the capacity of the cooling system on this vehicle if it is equipped with air conditioning?

_____ quarts _____ liters

f. What is the cylinder compression ratio for this vehicle's engine?

_____

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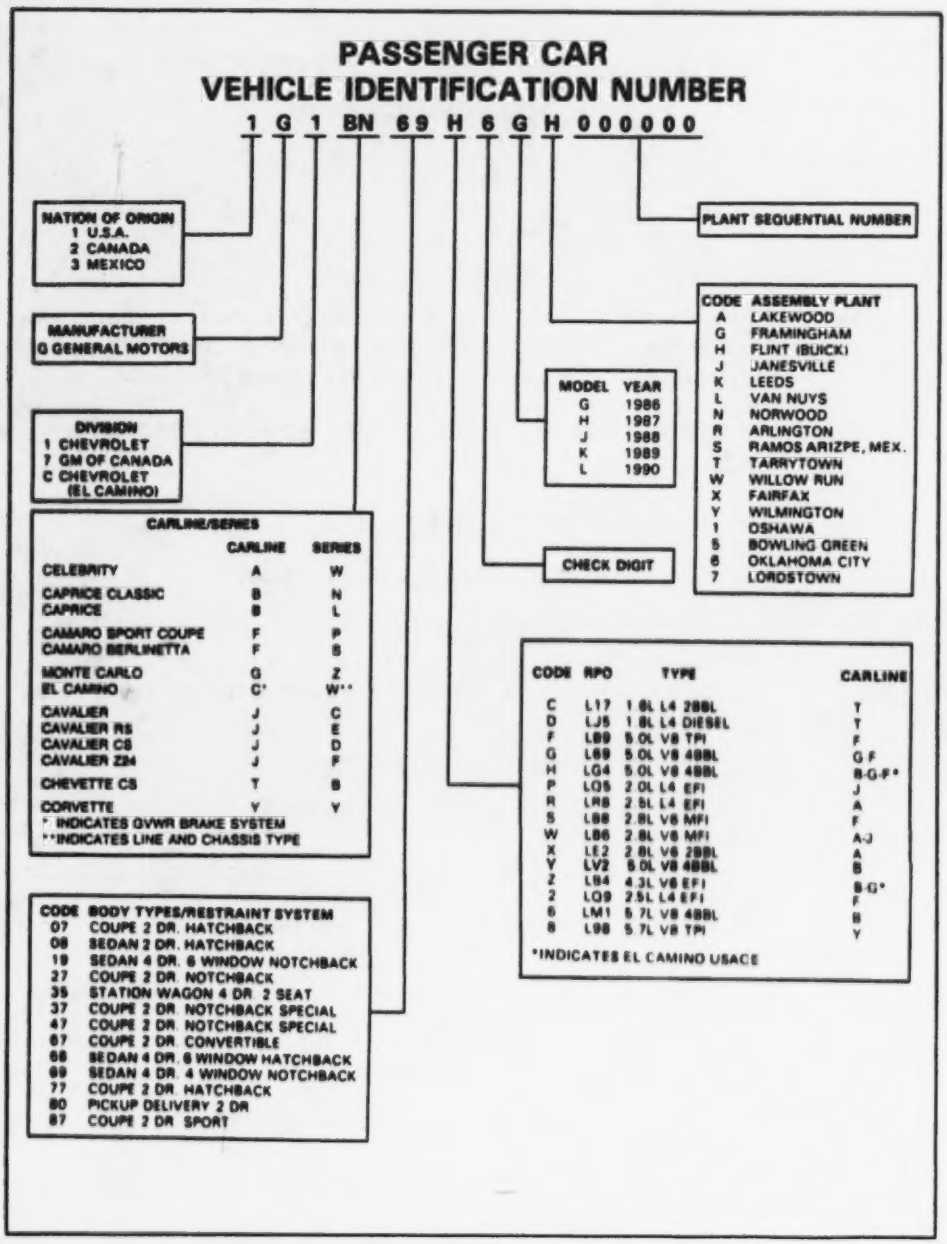
PASSENGER CAR
VEHICLE IDENTIFICATION NUMBER
1 G 1 BN 69 H 6 G H 000000
NATION OF ORIGIN
1 U.S.A.
2 CANADA
3 MEXICO
MANUFACTURER
G GENERAL MOTORS
DIVISION
1 CHEVROLET
7 GM OF CANADA
C CHEVROLET (EL CAMINO)
CARLINE/SERIES
CARLINE SERIES
CELEBRITY A W
CAPRICE CLASSIC B N
CAPRICE B L
CAMARO SPORT COUPE F P
CAMARO BERLINETTA F S
MONTE CARLO G Z
EL CAMINO C* W**
CAVALIER J C
CAVALIER RS J E
CAVALIER CS J D
CAVALIER Z24 J F
CHEVETTE CS T B
CORVETTE Y Y
* INDICATES GVWR BRAKE SYSTEM
** INDICATES LINE AND CHASSIS TYPE
CODE BODY TYPES/RESTRAINT SYSTEM
07 COUPE 2 DR. HATCHBACK
08 SEDAN 2 DR. HATCHBACK
19 SEDAN 4 DR. 6 WINDOW NOTCHBACK
27 COUPE 2 DR. NOTCHBACK
35 STATION WAGON 4 DR. 2 SEAT
37 COUPE 2 DR. NOTCHBACK SPECIAL
47 COUPE 2 DR. NOTCHBACK SPECIAL
67 COUPE 2 DR. CONVERTIBLE
68 SEDAN 4 DR. 6 WINDOW HATCHBACK
69 SEDAN 4 DR. 4 WINDOW NOTCHBACK
77 COUPE 2 DR. HATCHBACK
80 PICKUP DELIVERY 2 DR
87 COUPE 2 DR. SPORT
MODEL YEAR
G 1986
H 1987
J 1988
K 1989
L 1990
CHECK DIGIT
CODE RPO TYPE CARLINE
C L17 1 8L L4 2BBL T
D LJ5 1 8L L4 DIESEL T
F LB9 5 0L V8 TPI F
G L69 5 0L V8 4BBL G F
H LG4 5 0L V8 4BBL B-G-F*
P LQ5 2 0L L4 EFI J
R LR8 2 5L L4 EFI A
S LB8 2 8L V6 MFI F
W LB6 2 8L V6 MFI A-J
X LE2 2 8L V6 2BBL A
Y LV2 5 0L V8 4BBL B
Z LB4 4 3L V8 EFI B-G*
2 LQ9 2 5L L4 EFI F
6 LM1 5 7L V8 4BBL B
8 L98 5 7L V8 TPI Y
*INDICATES EL CAMINO USACE
PLANT SEQUENTIAL NUMBER
CODE ASSEMBLY PLANT
A LAKEWOOD
G FRAMINGHAM
H FLINT (BUICK)
J JANESVILLE
K LEEDS
L VAN NUYS
N NORWOOD
R ARLINGTON
S RAMOS ARIZPE, MEX.
T TARRYTOWN
W WILLOW RUN
X FAIRFAX
Y WILMINGTON
1 OSHAWA
5 BOWLING GREEN
6 OKLAHOMA CITY
7 LORDSTOWN

Used with permission of General Motors Corporation, Chevrolet Motor Division.

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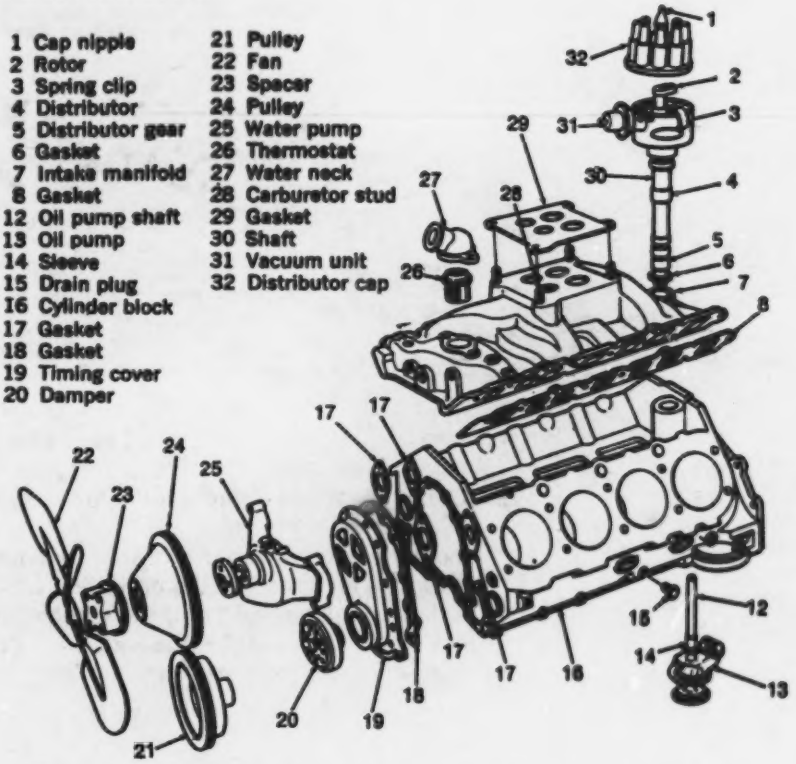
OBJECTIVE 4

Study the following illustrations and then answer the questions about each illustration. Write your answers in the spaces provided.

ILLUSTRATION A

1 Cap nipple
2 Rotor
3 Spring clip
4 Distributor
5 Distributor gear
6 Gasket
7 Intake manifold
8 Gasket
12 Oil pump shaft
13 Oil pump
14 Sleeve
15 Drain plug
16 Cylinder block
17 Gasket
18 Gasket
19 Timing cover
20 Damper
21 Pulley
22 Fan
23 Spacer
24 Pulley
25 Water pump
26 Thermostat
27 Water neck
28 Carburetor stud
29 Gasket
30 Shaft
31 Vacuum unit
32 Distributor cap



Used with permission of General Motors Corporation, Chevrolet Motor Division.

NOTE: For questions *a* through *c*, refer to Illustration A above.

a. What is part 15?

_____

b. What is part 31?

_____

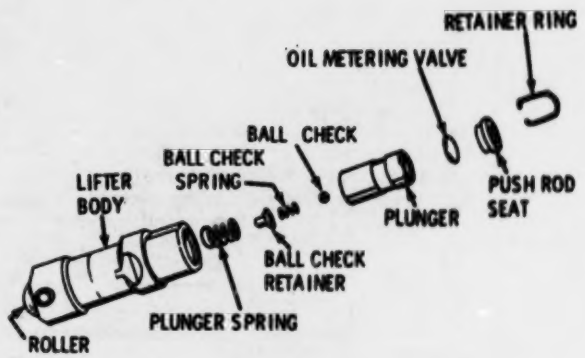
c. When installing the water pump on the engine, what is the correct order for installation of the following parts: gaskets, pulleys, timing cover, spacer, fan, and water pump?

_____

_____

_____

ILLUSTRATION B



Valve lifter disassembled

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *d* through *f*, refer to illustration B above.

d. The plunger goes into the lifter body. What is the correct sequence for installing the parts that are inside the lower portion of the plunger? List them beginning with the first part that would be put in the lifter body.

_____

_____

_____

e. How many springs are shown in the illustration?

_____

f. What part is installed between the plunger and the push rod seat?

_____

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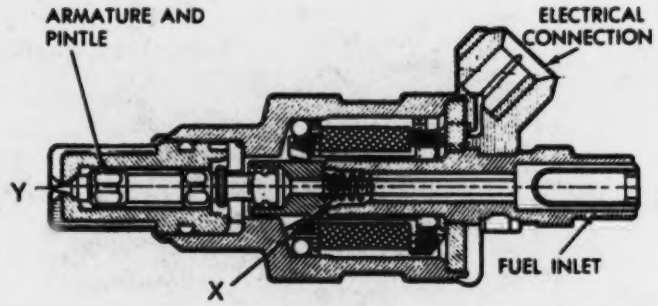
ILLUSTRATION C



Cross section of typical solenoid-type fuel injector

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *g* through *l*, refer to illustration C above.

g. What is the purpose of having lines running in different directions?

_____

h. Note that by comparing the line patterns on each side of line Y, you will find shapes and patterns that match each other. Which of the following is the most likely explanation for this fact?

_____1. A fuel injector has many parts that are assembled in matching pairs

_____2. This fuel injector is shaped something like a cylinder with Y as the centerline

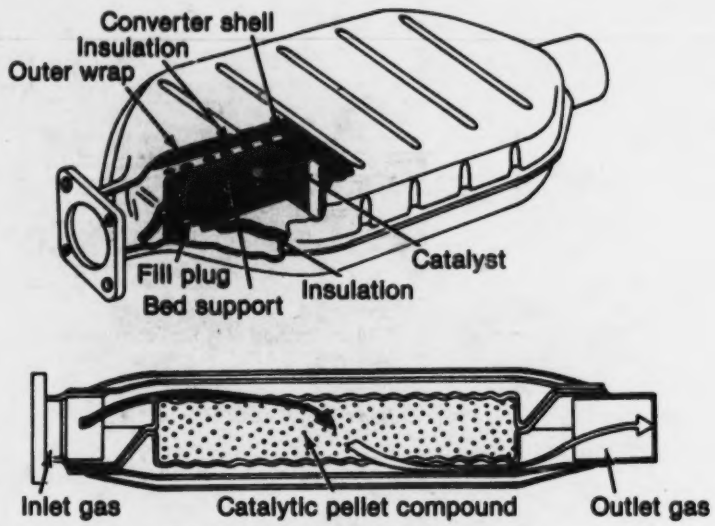
_____3. The artist ran out of patterns and had to repeat some of them

_____4. Fuel injector parts are color coded for easy identification

i. What type of part is indicated by the arrow marked with an "X"?

_____

ILLUSTRATION D



Pellet-type catalytic converter

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *j* through *l*, refer to Illustration D above.

j. One of the openings of this catalytic converter has a flange with bolt holes while the other is a straight tube. Is it the inlet or the outlet opening that has a flange?

_____

k. What is between the outer wrap and the converter shell?

_____

l. Is this converter designed so that exhaust gases enter the catalyst from the top or bottom?

_____

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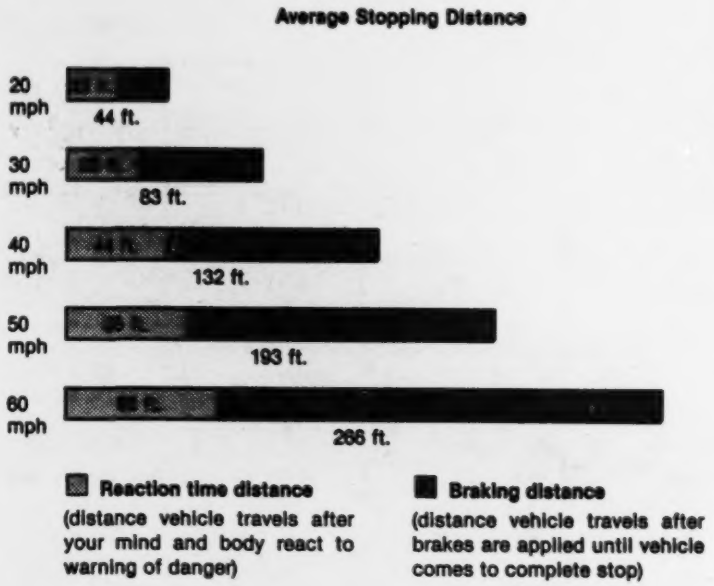
OBJECTIVE 5

Study the following graphs and answer the questions with each graph. Write your answers in the spaces provided or write an "X" in the blanks before the correct answers.

GRAPH A



NOTE: For questions *a* through *d*, refer to Graph A.

a. On the graph, two factors are shown that when added together give total stopping distance. What are those two factors?

_____

b. What is the total stopping distance at 60 mph?

_____

c. Which of the following is the *best* summary of the graph?

_____1. Reaction time distance increases as speed increases

_____2. Braking distance increases as speed increases

_____3. Stopping distance increases as speed increases

_____4. None of the above

d. What is the braking distance at 50 mph?

_____

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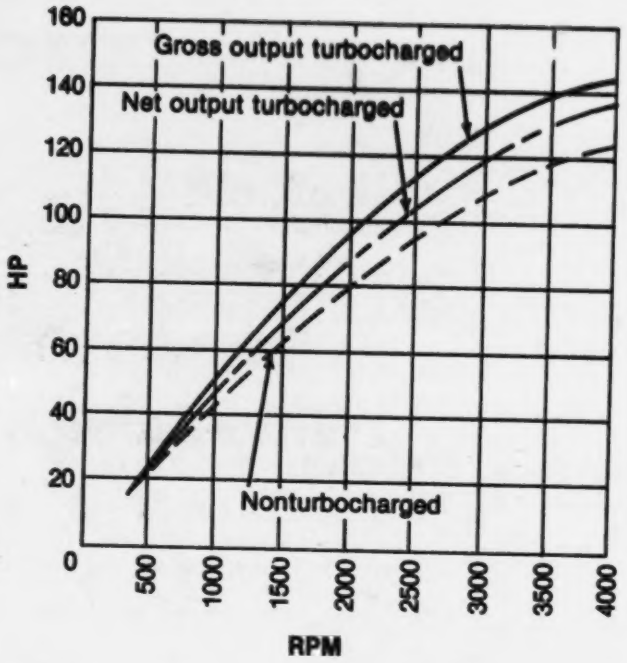
GRAPH B



Comparison of power from nonturbocharged and turbocharged engines

NOTE: For questions *e* through *h*, refer to Graph B.

e. Which of the following is the best summary of the graph?

_____1. A turbocharged engine produces more RPM than a nonturbocharged engine

_____2. The net turbocharged output is more than the gross turbocharged output

_____3. At a given RPM, a turbocharged engine will generally produce more horsepower (HP) than a nonturbocharged engine

_____4. Horsepower (HP) developed by a nonturbocharged engine begins to drop off at engine speeds over 3300 RPM

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f. What is the approximate gross output (in horsepower) of a turbocharged engine at 3000 RPM?

_____

g. How many horsepower (HP) are produced by a nonturbocharged engine at 2500 RPM?

_____

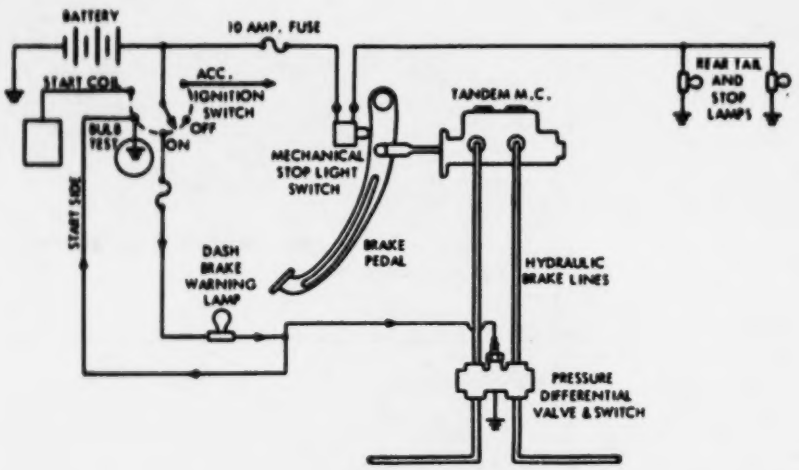
h. As RPM increases, does the difference between gross and net turbocharged HP increase or decrease?

_____

OBJECTIVE 6

Study the following diagrams and answer the questions with each diagram. Write your answers in the spaces provided or write an "X" in the blanks before the correct answers.

DIAGRAM A



Typical dual brake system

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *a* through *d*, refer to Diagram A.

a. What connects the tandem master cylinder (M.C.) to the pressure differential valve?

_____

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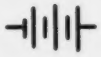
b. Depressing the brake pedal moves a plunger in the tandem master cylinder and also operates what part?

_____

c. Which of the following symbols is used to show the battery?

_____1.

_____2.

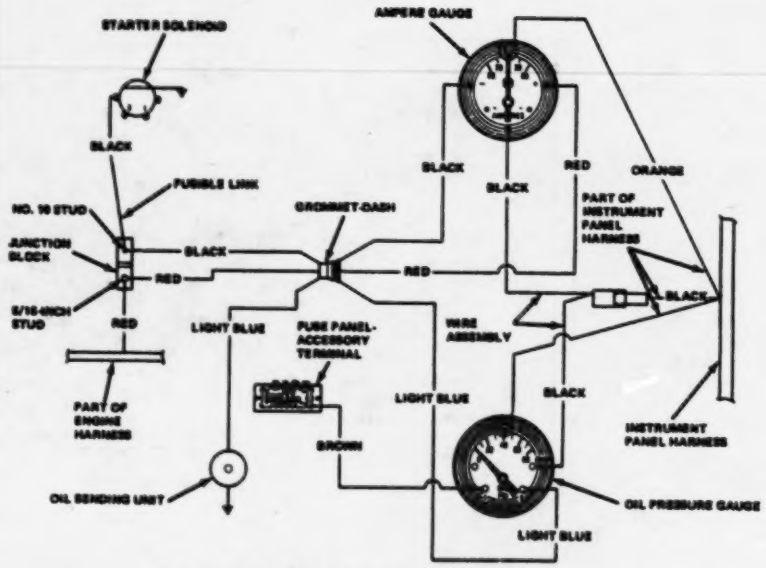
_____3. 

_____4.

d. What is in the circuit between the battery and the mechanical stop light switch?

_____

DIAGRAM B



Typical ammeter and oil pressure gauge wiring

Used with permission of Chrysler Motors Corporation.

NOTE: For questions *e* through *h*, refer to Diagram B.

e. What color is the wire between the oil sending unit and the oil pressure gauge?

_____

f. A device is indicated between the starter solenoid and the No. 10 stud of the junction block. What is this device called?

_____

g. Three wires pass through a grommet in the dash. What colors are these three wires?

_____

h. The red wire from the ampere gauge is connected to part of the junction block. What is this part of the junction block?

_____

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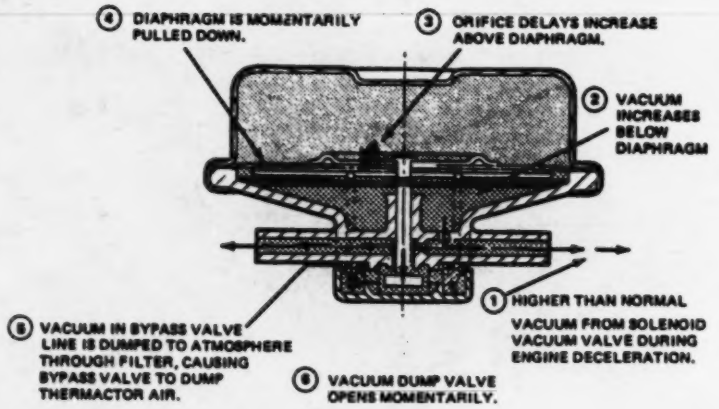
DIAGRAM C


4 DIAPHRAGM IS MOMENTARILY PULLED DOWN.
3 ORIFICE DELAYS INCREASE ABOVE DIAPHRAGM.
2 VACUUM INCREASES BELOW DIAPHRAGM
1 HIGHER THAN NORMAL VACUUM FROM SOLENOID VACUUM VALVE DURING ENGINE DECELERATION.
5 VACUUM IN BYPASS VALVE LINE IS DUMPED TO ATMOSPHERE THROUGH FILTER, CAUSING BYPASS VALVE TO DUMP THERMACTOR AIR.
6 VACUUM DUMP VALVE OPENS MOMENTARILY.

CUT-OFF OPERATION

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *i* through *l*, refer to Diagram C.

i. During engine deceleration, is vacuum from the solenoid vacuum valve higher or lower than normal?

_____

j. At 3 in the diagram, a part is indicated by an arrow. What is this part?

_____

k. Vacuum in the bypass valve is dumped to atmosphere through a particular part. What part is it?

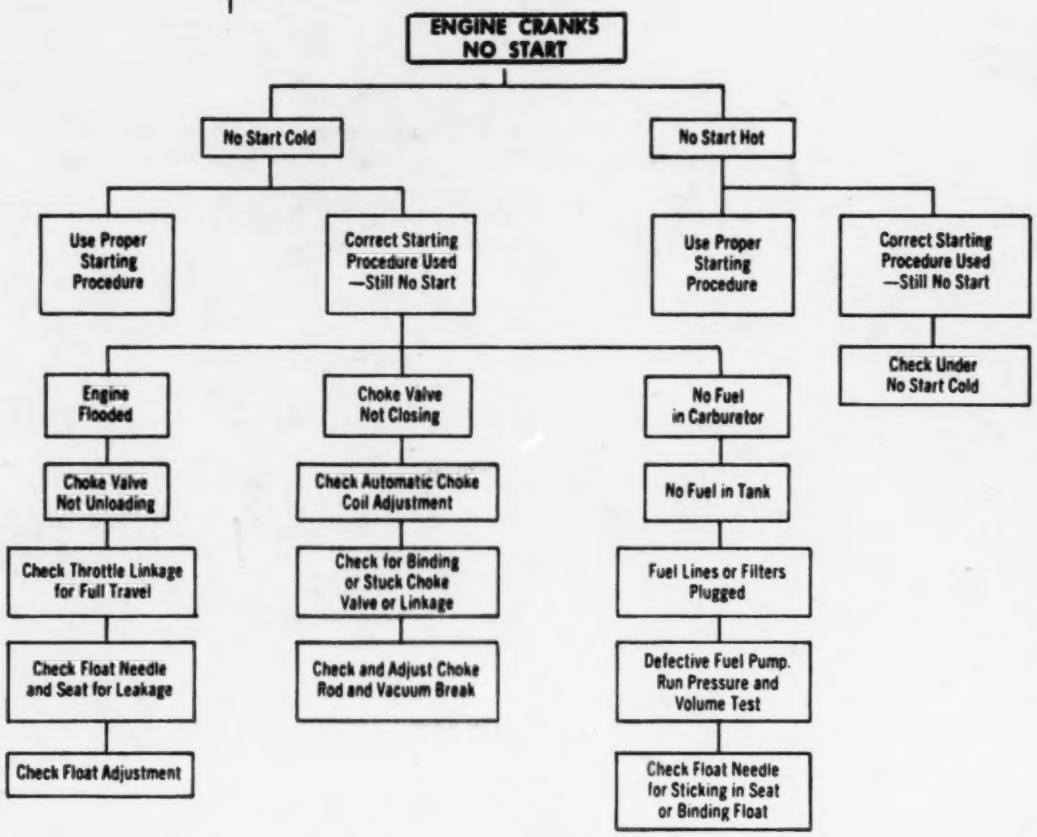
_____

l. In the sequence of steps for cut-off operation, what is the last step?

_____

_____

DIAGRAM D


ENGINE CRANKS NO START
No Start Cold
No Start Hot
Use Proper Starting Procedure
Correct Starting Procedure Used —Still No Start
Use Proper Starting Procedure
Correct Starting Procedure Used —Still No Start
Check Under No Start Cold
Engine Flooded
Choke Valve Not Closing
No Fuel in Carburetor
Choke Valve Not Unloading
Check Automatic Choke Coil Adjustment
No Fuel in Tank
Check Throttle Linkage for Full Travel
Check for Binding or Stuck Choke Valve or Linkage
Fuel Lines or Filters Plugged
Check Float Needle and Seat for Leakage
Check and Adjust Choke Rod and Vacuum Break
Defective Fuel Pump. Run Pressure and Volume Test
Check Float Adjustment
Check Float Needle for Sticking in Seat or Binding Float

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *m* through *p*, refer to Diagram D.

m. If the engine will not start even though it cranks, the first thing the operator should make sure of is that the proper _____ _____ is being used.

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n. This diagram covers no-start problems connected to carburetor operation. If the proper starting procedure is used and the vehicle still will not start, the three *most likely* carburetor problems are:

1. _____

2. _____

3. _____

o. If the engine is hot and floods when the proper starting procedure is used, which of the following is probably **not** a cause?

_____1. Choke valve not unloading

_____2. No fuel in tank

_____3. Incorrect float adjustment

_____4. Throttle linkage not traveling fully

p. If a defective fuel pump is suspected due to no fuel in the carburetor, what should the service person do next?

_____

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OBJECTIVE 7

Study the following tables and answer the questions with each table. Write your answers in the spaces provided.

TABLE A

GENERAL ENGINE SPECIFICATIONS
CHEVROLET CORVETTE

Year	Engine No. of Cyl.-Displacement (Cu. In.)	Engine VIN Code	Fuel Delivery	Horsepower @ rpm①	Torque @ rpm (fts. lbs.)①	Bore x Stroke (in.)	Compression Ratio	Oil Pressure @ 2000 rpm
'78	8-350	L	4 bbl.	185 @ 4000	280 @ 2400	4.000 x 3.480	8.4:1	40
	8-350	4	4 bbl.	220 @ 5200	280 @ 3600	4.000 x 3.480	8.9:1	40
'79	8-350	8	4 bbl.	195 @ 4000	285 @ 3200	4.000 x 3.480	8.2:1	45
	8-350	4	4 bbl.	225 @ 5200	270 @ 3600	4.000 x 3.480	8.9:1	45
'80	8-305	H	4 bbl.	180 @ 4200	255 @ 2000	3.736 x 3.480	8.6:1	45
	8-350	8	4 bbl.	190 @ 4400	280 @ 2400	4.000 x 3.480	8.2:1	45
	8-350	6	4 bbl.	230 @ 5200	275 @ 3600	4.000 x 3.480	9.0:1	45
'81	8-350	6	4 bbl.	190 @ 4200	280 @ 1600	4.000 x 3.480	8.2:1	45
'82	8-350	8	TBI	200 @ 4200	285 @ 2800	4.000 x 3.480	9.0:1	45
'84	8-350	8	TBI	205 @ 4300	290 @ 2800	4.000 x 3.480	9.0:1	50-65
'85	8-350	NA	MFI	240 @ 4300	330 @ 2900	4.000 x 3.480	9.0:1	50-65

NOTE: All engines used in the Corvette are manufactured by Chevrolet Motor Division, G.M. Corp.
NA—Not available at time of publication
TBI—Throttle body fuel injection system
MFI—Multiport fuel injection system
①Horsepower and torque are SAE net figures. They are measured at the rear of the transmission with all accessories installed and operating. Since the figures vary when a given engine is installed in different models, some are representative rather than exact.

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *a* through *e*, refer to Table A.

a. Explain how horsepower figures given in this table were measured.

_____

_____

_____

b. For a 1981 Corvette, what is the compression ratio?

_____

c. What type of fuel delivery was used on 1984 Corvettes?

_____

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d. What should the oil pressure be for a 1985 Corvette operating at 2000 rpm?

e. In which year covered by this table did Corvette have two different sizes of engines?

TABLE B

CAPACITIES—PINTO/BOBCAT/MUSTANG II

Year	Engine No. Cyl. Displacement (Cu. In.)	Engine Crankcase Add 1 Qt For ■ New Filter	TRANSMISSION Pts To Refill After Draining 4-Speed Manual	TRANSMISSION Pts To Refill After Draining Automatic (Total capacity)	Drive Axle (pts)	Gasoline Tank (gals)	Cooling System (qts) With Heater	Cooling System (qts) With A/C
'78	4-140 (2300 cc) Pinto, Bobcat	4.0	2.8	①	2.3②	13③	8.6	9.0
	4-140 (2300 cc) Mustang II	4.0	3.5	①	3.0	13④	8.8	9.1
	6-171 (2800 cc) Pinto, Bobcat	4.5	2.8	①	4.5	13③	8.5	9.2
	6-171 (2800 cc) Mustang II	4.5	3.5	①	4.5	13④	8.5	9.0
	8-302 (4950)	4.0	3.5	①	4.5	13④	16.3	16.3
'79-'80	4-140 (2300 cc)	4.0	2.8	①	2.5②	13③ ⑤	8.6	9.0
	6-171 (2800 cc)	4.5	2.8	①	4.5	13③ ⑤	8.5	9.1

■ ½ quart for 2800
— Not applicable
① C3 trans.—16; C4 trans.—14
② 8.00 in. axle—4.5
③ 14 gals on station wagon
④ 16.5 gals with auxiliary tank in Mustang II
⑤ Optional on some 1979-80 models—11.7

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *f* through *i*, refer to Table B.

f. How many gallons will the fuel tank on a 1978 Pinto station wagon hold?

g. How many pints of transmission fluid are required to fill a C4 transmission on a 1980 Mustang II with a 171-cubic-inch engine?

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h. How many quarts of oil are required if the crankcase is to be filled during an oil and filter change for the following vehicles?

1. 1978 Bobcat, 140-cubic-inch engine

   _____ qts.

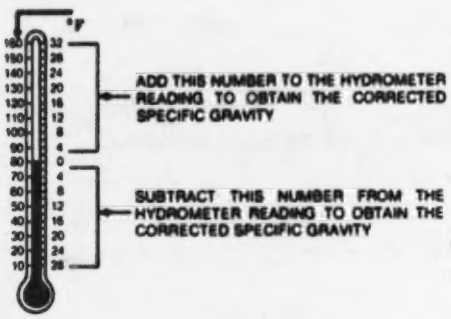
2. 1978 Mustang II, 171-cubic-inch engine

   _____ qts.

i. How many quarts of coolant are required in a 1980 Mustang II with a 171 cubic-inch engine and an air conditioner?

_____

TABLE C


°F
ADD THIS NUMBER TO THE HYDROMETER READING TO OBTAIN THE CORRECTED SPECIFIC GRAVITY
SUBTRACT THIS NUMBER FROM THE HYDROMETER READING TO OBTAIN THE CORRECTED SPECIFIC GRAVITY

Specific Gravity (@ 80° F.)

Minimum	*Battery Charge*
1.260	100% Charged
1.230	75% Charged
1.200	50% Charged
1.170	25% Charged
1.140	Very Little Power Left
1.110	Completely Discharged

The effects of temperature on battery specific gravity (left) and amount of battery charge in relation to specific gravity (right)

From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

NOTE: For questions *j* through *n*, refer to Table C.

j. For what temperature is this table of specific gravity readings designed?

_____

k. A minimum reading of 1.200 means what percentage of charge?

_____

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l. If the temperature of the electrolyte is 120°F, what must be done to correct the hydrometer reading for the table?

_____

_____

m. If the hydrometer reading at 70°F is 1.260, what is the percent of charge in the battery?

_____

n. Generally, as the specific gravity reading decreases, does the percentage of battery charge increase or decrease?

_____

OBJECTIVE 8

The following questions will require you to use automotive service reference materials to find the answers. Your instructor will make the required reference materials available to you.

NOTE: Questions *a* through *e* pertain to late-model American Motors Corporation vehicles.

a. The 151-cubic-inch engine used in some AMC vehicles during the early 1980s was manufactured by what company?

_____

b. What is the firing order of the AMC 150-cubic-inch engine?

_____

c. On AMC Eagles, what other part must be replaced if lower ball joints must be replaced? (Ball joints are part of the front suspension.)

_____

d. Some AMC steering wheel shafts use metric threads. What is used to identify these shafts as metric?

_____

_____

e. What type of oil filter design must be installed on the 121-cubic-inch engine used in some AMC vehicles?

_____

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NOTE: Questions *f* through *j* pertain to late-model Chrysler Corporation front-wheel-drive vehicles.

f. The 105-cubic-inch (1.7L) engine used in some early 1980s model Chrysler vehicles were manufactured by what company?

_____

g. What is the firing order of the 2.2L engine?

_____

h. What adjustment procedures are required for the intake and exhaust valves of the 2.2L engine?

_____

i. In what position must the ignition switch be for installation or removal of an ignition switch for a Dodge Omni?

_____

j. When installing a piston in a 2.2L engine, should the arrow marked in the top of the piston face the front or the rear of the engine?

_____

NOTE: Questions *k* through *o* pertain to late-model, front-wheel-drive General Motors Corporation A and X body vehicles.

k. What is the firing order of the 173-cubic-inch (2.8L) engine?

_____

l. Some 173-cubic-inch engines use gaskets for their valve covers while others use silicone sealant. Can a gasket be used in place of sealant or sealant in place of a gasket?

_____

m. If the rocker arms have been removed from a 4.3L diesel engine, what procedure must be accomplished prior to reinstalling them?

_____

_____

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n. How many quarts of oil are required to refill the crankcase after an oil and filter change for a 2.5L engine?

A-Body _____ X-Body _____

o. Ignition timing and other specifications may change during the manufacturing life of a vehicle model. What should the service person check for most accurate ignition timing specifications?

_____

NOTE: Questions *p* through *t* pertain to late-model, front-wheel-drive Ford Motor Company vehicles.

p. What company manufactured the 2.0L diesel engine used in some Fords?

_____

q. When adjusting idle speed control on a 1.6L engine, should the engine cooling fan be running or disconnected?

_____

r. How is the 2.3L engine removed from the vehicle?

_____

_____

s. If you have to remove an automatic transaxle (ATX) from an Escort or Lynx, which halfshaft assembly must be removed first?

_____

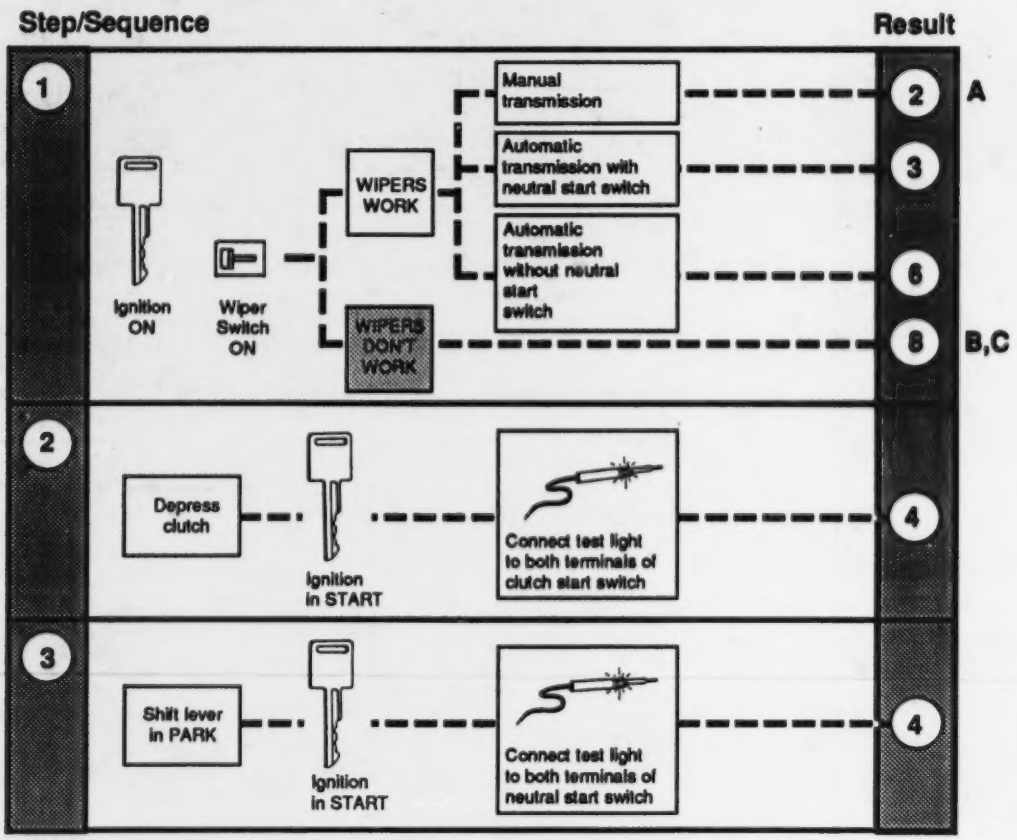
t. How many replacement quarts of oil are required after an oil and filter change on a 2.0L engine?

_____

OBJECTIVE 9

Imagine that you are responsible for troubleshooting three vehicles that will not start: Vehicle A, Vehicle B, and Vehicle C. Use the chart on this and the next two pages and what you know about troubleshooting to determine what is wrong with the three vehicles. Then answer the following questions.

NOTE: The letters of the vehicles are written next to the numbers in the results column where they apply. For example, Vehicle A has a manual transmission, so an *A* appears beside the *2* in the results column. Vehicle C has wipers that will not work. However, after Step 1, if a result applies to a vehicle, its letter appears next to the result column even if the troubleshooting procedure should not have led you to that block. For example, at Step 9, Vehicle C is listed as starting after the battery was replaced. That does not mean that battery replacement was required. It simply means that if the battery were replaced, Vehicle C would start. Vehicles A and B would not start if the battery were replaced.



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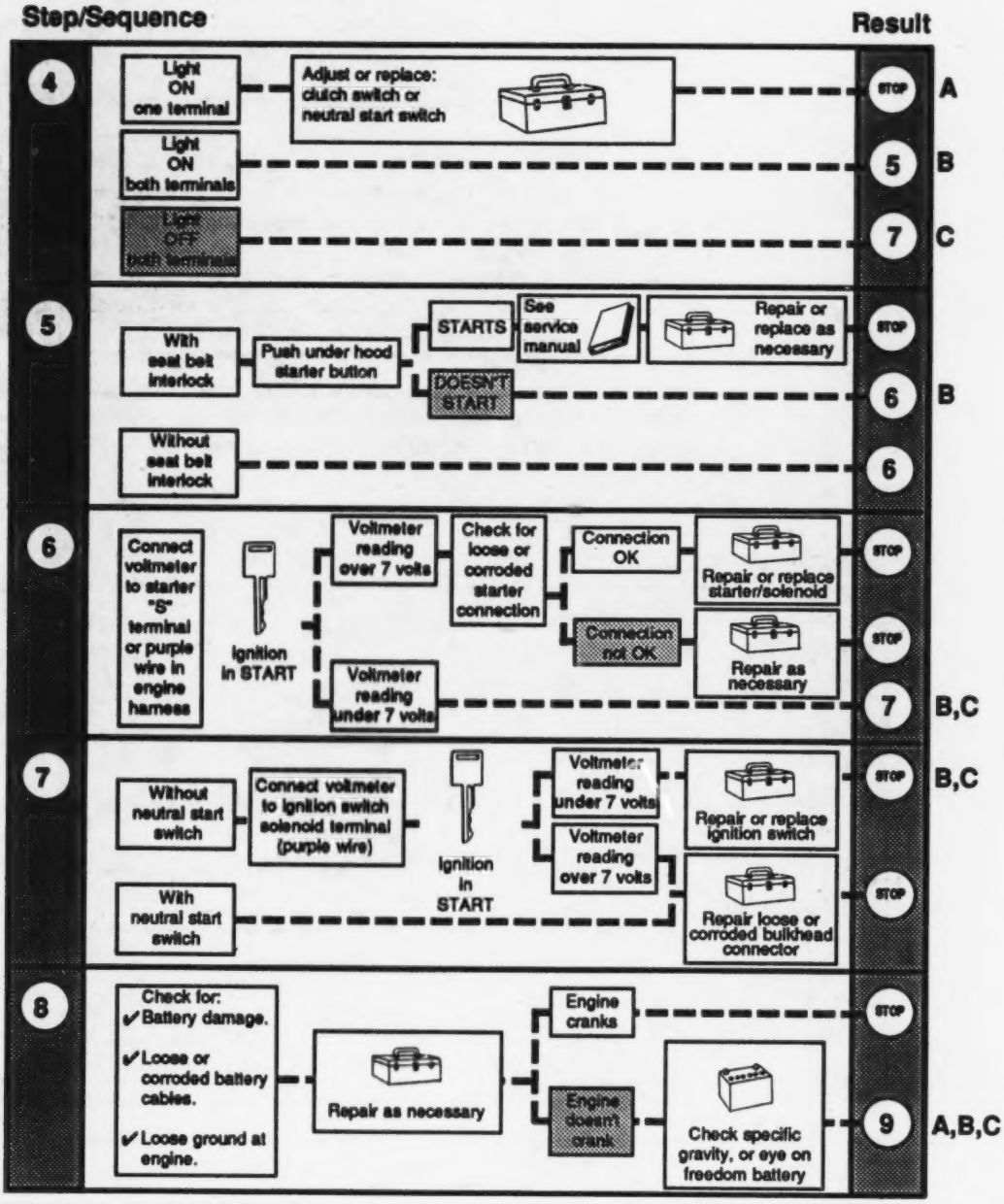
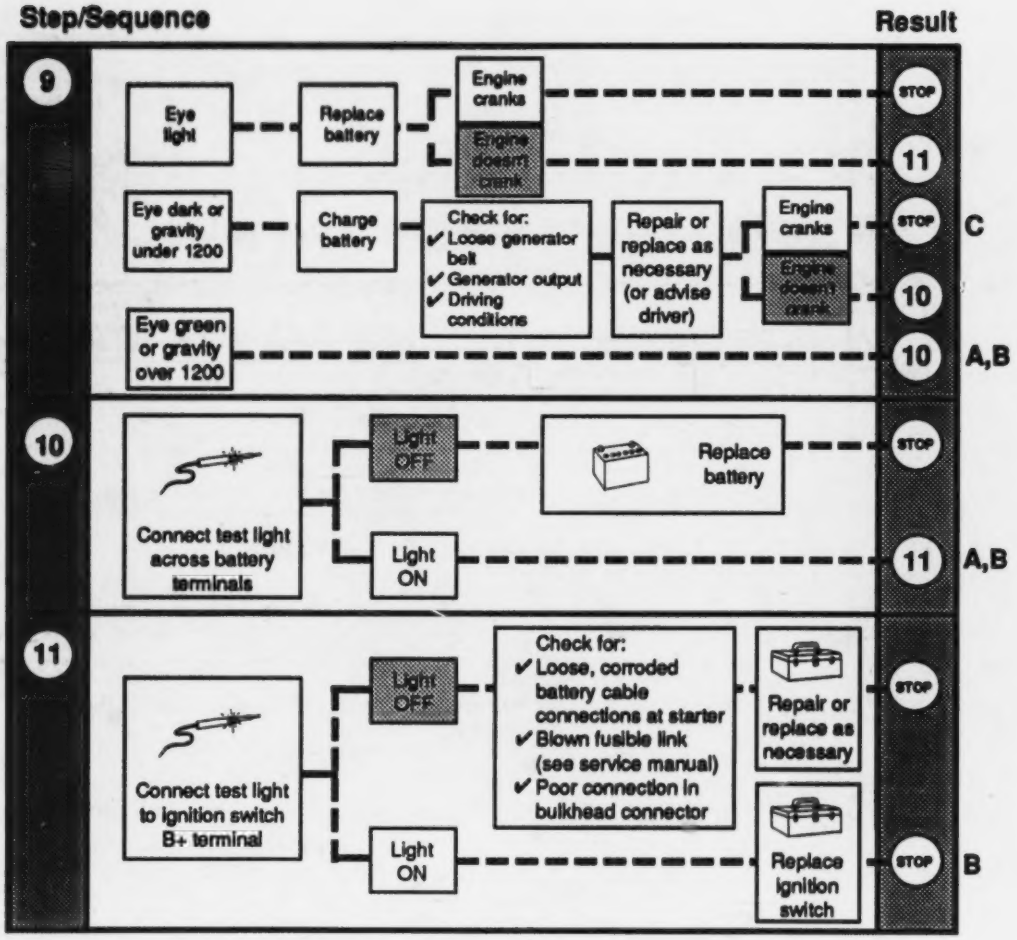

Step/Sequence
Result
4
Light ON one terminal
Adjust or replace: clutch switch or neutral start switch
STOP
A
Light ON both terminals
5
B
Light OFF both terminals
7
C
5
With seat belt interlock
Push under hood starter button
STARTS
See service manual
Repair or replace as necessary
STOP
DOESN'T START
6
B
Without seat belt interlock
6
6
Connect voltmeter to starter "S" terminal or purple wire in engine harness
Ignition in START
Voltmeter reading over 7 volts
Check for loose or corroded starter connection
Connection OK
Repair or replace starter/solenoid
STOP
Connection not OK
Repair as necessary
STOP
Voltmeter reading under 7 volts
7
B,C
7
Without neutral start switch
Connect voltmeter to ignition switch solenoid terminal (purple wire)
Ignition in START
Voltmeter reading under 7 volts
Repair or replace ignition switch
STOP
B,C
Voltmeter reading over 7 volts
With neutral start switch
Repair loose or corroded bulkhead connector
STOP
8
Check for:
✔ Battery damage.
✔ Loose or corroded battery cables.
✔ Loose ground at engine.
Repair as necessary
Engine cranks
STOP
Engine doesn't crank
Check specific gravity, or eye on freedom battery
9
A,B,C


Step/Sequence
Result
9
Eye light
Replace battery
Engine cranks
Engine doesn't crank
STOP
11
Eye dark or gravity under 1200
Charge battery
Check for:
✔ Loose generator belt
✔ Generator output
✔ Driving conditions
Repair or replace as necessary (or advise driver)
Engine cranks
Engine doesn't crank
STOP
10
C
Eye green or gravity over 1200
10
A,B
10
Connect test light across battery terminals
Light OFF
Replace battery
STOP
Light ON
11
A,B
11
Connect test light to ignition switch B+ terminal
Light OFF
Check for:
✔ Loose, corroded battery cable connections at starter
✔ Blown fusible link (see service manual)
✔ Poor connection in bulkhead connector
Repair or replace as necessary
STOP
Light ON
Replace ignition switch
STOP
B

a. If you consider the fact that the headlights are directly connected to the battery, what additional component is tested in Step 1 of this procedure that is not tested in the other troubleshooting procedure you have studied?

_____

NOTE: Questions *b* and *c* are for Vehicle A.

b. What was the cause of the failure to start?

_____

c. What test indication showed this to be the problem?

_____

_____

NOTE: Questions *d* through *f* are for Vehicle B.

d. What was the cause of the failure to start?

_____

_____

e. At which step should you have discovered the problem?

_____

f. Steps 9 and 10 eliminated what component as a probable cause of the no-start condition?

_____

NOTE: Questions *g* through *i* are for Vehicle C.

g. What was the cause of the no-start problem?

_____

h. At what step should you have discovered the problem?

_____

i. In Step 1, what was the cause of the wipers not working?

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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WRITTEN TEST ANSWERS	USE AUTOMOTIVE SERVICE REFERENCE MATERIALS

OBJECTIVE 1

a. 1
b. 4
c. 3
d. 3
e. 1
f. 2
g. 1
h. 1
i. 2

OBJECTIVE 2

a. 3, 4
b. 1, 2
c. 3
d. 1, 3
e. 4
f. 3
g. 3
h. 1, 2

OBJECTIVE 3

a. 1987 Chevrolet Cavalier RS
b. 2.0L L4 EFI
c. Coupe 2 door sport
d. Oklahoma City
e. 8.3; 7.7
f. 9.3:1

OBJECTIVE 4

a. Drain plug
b. Vacuum unit
c. Gaskets, timing cover, water pump, pulleys, spacer, fan
d. Plunger spring, ball check retainer, ball check spring, ball check
e. 2
f. Oil metering valve
g. To distinguish among different components
h. 2
i. Spring
j. Inlet
k. Insulation
l. Top

OBJECTIVE 5

a. Reaction time distance, braking distance
b. 266 feet
c. 3
d. 138 feet
e. 3
f. 130 HP
g. 90-100
h. Increase

OBJECTIVE 6

a. Hydraulic brake lines
b. Mechanical stop light switch
c. 3
d. 10 amp fuse
e. Light blue
f. Fusible link
g. Red, black, light blue
h. 5/16-inch stud
i. Higher than normal
j. Orifice
k. Filter
l. Vacuum dump valve opens momentarily
m. Starting procedure
n. 1. Engine flooded
   2. Choke valve not closing
   3. No fuel in carburetor
o. 2
p. Run pressure and volume test

OBJECTIVE 7

a. They are measured at the rear of the transmission with all accessories installed and operating
b. 8.2:1
c. Throttle body fuel injection system
d. 50 to 65
e. 1980
f. 14
g. 14
h. 1. 5
   2. 5
i. 9.1
j. 80°F
k. 50%
l. Add +16 to the hydrometer reading
m. 75%
n. Decrease

OBJECTIVE 8

a. Pontiac
b. 4-3-2-1
c. The control arms
d. Shaft splines have a groove, and nuts are painted blue
e. One with a built-in bypass valve
f. Volkswagen
g. 1-3-4-2
h. None; they are not adjustable
i. LOCK
j. Front
k. 1-2-3-4-5-6
l. No
m. The valve lifters must be bled down
n. **A-Body**—3.0
   B-Body—4.0
o. Underhood sticker
p. Mazda
q. Running
r. From underneath with the transaxle attached
s. Right
t. 7.2

OBJECTIVE 9

a. Ignition switch
b. A bad clutch start switch
c. Test light on only one terminal of the clutch start switch
d. A defective ignition switch
e. Step 11
f. The battery
g. A weak battery
h. Step 9
i. The weak battery

OBJECTIVE SHEET

UNIT B-2 REMOVE AND INSTALL COMMON FASTENERS

INTRODUCTION

Vehicles are manufactured with many parts, all of various sizes and made from various materials. The parts are assembled to work together to do the varied functions required for the vehicle to operate properly—the delivery and combustion of fuel, the removal of exhaust gases, the cooling and lubrication of the engine, the provision of comfort and convenience to passengers, the control of stopping and steering, and other requirements for safe, efficient operation. Obviously, some force is required to hold these parts together. This force comes in many forms referred to as *fasteners*. These designs include nuts, bolts, screws, pins, clips, springs, clamps, and many other devices. Fasteners often undergo tremendous strains in holding assembled parts together, and a vehicle could quite literally fall apart if fasteners are not properly installed. The information and skills covered in this unit can help the student become familiar with common types of fasteners used in automotive construction and become able to use tools required to remove and install these fasteners.

UNIT OBJECTIVE

After completing this unit, the student should be able to remove and install common automotive fasteners in accordance with industry standards. The student will demonstrate these competencies by completing the assignment sheets, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit B-1, "Use Automotive Service Reference Materials."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with common fasteners by choosing the correct definition from a list of four choices.

2. Recall methods for holding threaded fasteners by naming illustrated methods.

3. Identify threaded fasteners by their characteristics. (Assignment Sheet 1)

4. Select correct threaded fasteners for specific applications. (Assignment Sheet 2)

5. Select correct tools to use in removing and installing threaded fasteners. (Assignment Sheet 3)

6. Apply guidelines for the use of threaded fasteners. (Assignment Sheet 4)

7. Select correct nonthreaded fasteners for specific applications. (Assignment Sheet 5)

8. Select correct tools to use with nonthreaded fasteners. (Assignment Sheet 6)

9. Inspect and replace air filter. (Job Sheet 1)

10. Replace PCV valve. (Job Sheet 2)

11. Replace fuel filter. (Job Sheet 3)

12. Remove and reinstall tire-and-wheel assemblies. (Job Sheet 4)

13. Remove and install hoses. (Job Sheet 5)

14. Inspect and replace shock absorbers. (Job Sheet 6)

15. Aim headlights. (Job Sheet 7)

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SUGGESTED ACTIVITIES	REMOVE AND INSTALL COMMON FASTENERS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit.

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare classroom and shop. Display posters, charts, and safety signs, etc., related to fasteners and tools used in the automotive shop.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss introduction to the unit (see Objective Sheet). Explain to students that there are a variety of fasteners and that there are many types of fasteners, other than threaded fasteners such as screws and bolts, which are used in automotive service. Discuss the functions of fasteners used in automotive service and the importance of understanding the different functions.

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive service specialist. Also relate the objectives to your introduction and to materials previously covered.

Objective 1 Recognize definitions of terms associated with common fasteners

- Discuss terms, and show students examples of terms as appropriate. Include as examples both threaded and nonthreaded fasteners.

- Discuss the terms *threaded* and *tapped hole*, explaining to students that after a hole has been tapped, it has threads. Relate that fasteners may be threaded, but that the external threads of a fastener are made with a tool called a *die*.

Objective 2 Recall methods for holding threaded fasteners

- Discuss the methods for holding threaded fasteners, and show students examples of as many of the methods as possible.

- Tell students of instances where each of these methods for holding threaded fasteners is used.

Objectives 3-8

- Have students read Student Supplements 1 through 3, and then discuss in class. Have students complete Assignment Sheet 1, "Identify Threaded Fasteners by Their Characteristics," and Assignment Sheet 2, "Select Correct Threaded Fasteners for Specific Applications."

- Have students read Student Supplement 4, "Tools Used to Remove and Install Threaded Fasteners," and then complete Assignment Sheet 3, "Select Correct Tools to Use in Removing and Installing Threaded Fasteners."

- Have students read Student Supplement 5, "Guidelines for the Use of Threaded Fasteners." Show and discuss Transparencies 1 through 3. Have students complete Assignment Sheet 4, "Apply Guidelines for the Use of Threaded Fasteners."

- Have students read Student Supplement 6, "Nonthreaded Fasteners," and then complete Assignment Sheet 5, "Select Correct Nonthreaded Fasteners for Specific Applications."

- Have students read Student Supplement 7, "Tools Used to Remove and Install Nonthreaded Fasteners," and then complete Assignment Sheet 6, "Select Correct Tools to Use with Nonthreaded Fasteners."

Objectives 9-15

- Discuss equipment and materials used in each job sheet. Review with students applicable safety rules and precautions and the guidelines given in each job-sheet introduction.

- Demonstrate Job Sheet 1, "Inspect and Replace Air Filter." Have students practice Job Sheet 1 until they are ready to take the practical test.

- Demonstrate Job Sheet 2, "Replace PCV Valve." Have students practice Job Sheet 2 until they are ready to take the practical test.

- Have students read Supplement 1, "Fuel Filters." Demonstrate Job Sheet 3, "Replace Fuel Filter." Have students practice Job Sheet 3 until they are ready to take the practical test.

- Demonstrate Job Sheet 4, "Remove and Reinstall Tire-and-Wheel Assemblies." Have students practice Job Sheet 4 until they are ready to take the practical test.

- Have students read Supplement 2, "Hoses." Demonstrate Job Sheet 5, "Remove and Install Hoses." Have students practice Job Sheet 5 until they are ready to take the practical test.

- Have students read Supplement 3, "Shock Absorbers." Demonstrate Job Sheet 6, "Inspect and Replace Shock Absorbers." Have students practice Job Sheet 6 until they are ready to take the practical test.

- Demonstrate Job Sheet 7, "Aim Headlights." Have students practice Job Sheet 7 until they are ready to take the practical test.

EVALUATION

- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- *Chilton's Auto Repair Manual 1985: Domestic and Canadian Cars from 1978 through 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.
- Crouse, William H. *Motor Vehicle Inspection.* New York: McGraw-Hill Book Company, 1978.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics,* 9th ed. New York: Gregg Division, McGraw-Hill Book Company, 1985.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- *Engine Tune-Up Service, Unit 5: Fuel and Carburetion Systems,* 2nd ed. Tallahassee, Florida: Florida Department of Education, 1982.
- DeKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Henderson, Chuck, and Ivan Armstrong. *Auto Mechanics I.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1976.
- Hendrix, Laborn J. "Bud." *Fundamentals of Carpentry.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center and The Associated General Contractors of America, 1985.
- *Introduction to Automotive Mechanics, Unit 1: Hand Tools, Automotive, Fasteners, Shop Equipment and Supplies,* rev. ed. Tallahassee, Florida: Florida Department of Education, 1982.
- Litton, Bill, and James Sharpton. *Introduction to Auto Body.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1985.

- Mitchell Information Services, Inc. *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Motor Auto Repair Manual,* 49th ed. New York, New York: The Hearst Corporation, 1985.
- *1984 Shop Manual: Impala, Caprice, Classic, Malibu Classic, Monte Carlo and El Camino.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1984.
- *1985 Chrysler Engine-Chassis-Body Service Manual: 1985 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corporation, 1984.
- *1985 Shop Manual: Caprice, Impala, Monte Carlo and El Camino.* Detroit, Michigan: General Motors Corporation, Chevrolet Motor Division, 1985.
- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corporation, 1985.
- Patton, Bob, and Keith Harp. *Vocational Agriculture I.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1984.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1982.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1984.
- Toboldt, William K., and Larry Johnson. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1983.

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SUPPLEMENT 1

Fuel Filters

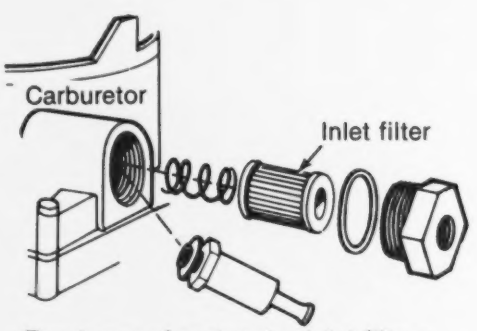
INTRODUCTION

The internal combustion engine works by burning a mixture of fuel and air. The air is filtered to provide a clean mixture by removing dust and other particles from the air. To ensure that the combustion is free of particles that will not burn or that will keep the mixture from burning evenly, the fuel mixture—whether gasoline or diesel—must also be filtered. For this reason, vehicles are equipped with one or more fuel filters. These filters are of various designs and may be located anywhere in the line that carries fuel from the tank to the carburetor or injectors. Eventually, fuel filters become clogged, develop leaks, or no longer provide adequate filtration. When this happens, a vehicle may quit running due to fuel starvation or may run roughly due to poorly filtered fuel or an inconstant flow of fuel. Though some filters can be cleaned, most are not normally serviceable, and must be replaced. You will learn how to replace fuel filters in Job Sheet 3. This supplement will prepare you to learn that skill by teaching you about fuel filter design and operation.

TYPES OF FILTERS

There are three types of filters used in automotive fuel systems: enclosed filters, in-line filters, and pressure filters. Enclosed filters are built into the vehicle's fuel system as a part of system components. For example, many fuel tanks have filters or screens. Some vehicles have filter housings built into the fuel pump or into the carburetor, as shown in Figure 1 below.

FIGURE 1



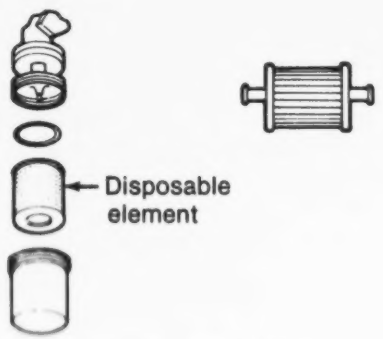
Two types of carburetor inlet filters

From *Engine Tune-Up Service, Unit 5: Fuel and Carburetion Systems*, 2nd ed., ©1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

The filtering element in enclosed filters may be cleanable or disposable. Cleanable elements are made of wire meshes or specially heated (sintered) bronze. Disposable elements are generally made of paper, but may be made of other porous materials such as a ceramic substance.

In-line filters are so named because they are installed in the fuel-line portion of the system. Fuel traveling through the line must go through the filter, which is often located between the fuel pump and the carburetor. In-line filters may be removed and replaced as a single unit or they may contain disposable elements. These two types are shown in Figure 2 below.

FIGURE 2



In-line fuel filters

From *Engine Tune-Up Service, Unit 5: Fuel and Carburetion Systems*, 2nd ed., © 1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

The disposable in-line filter is the most commonly used design. However, some vehicles, especially those using diesel fuel, may have in-line filters that have disposable elements, such as the bowl- and canister-type in-line filters. These are used in diesel systems to remove water that accumulates in the fuel.

Pressure fuel filters are used in some fuel-injection systems. These filters are designed to withstand and limit the higher pressures used for fuel-injection systems.

Many vehicles will be equipped with more than one fuel filter, and these filters may be of various types even on a particular make and model of vehicle.

SUPPLEMENT 2

Hoses

INTRODUCTION

Rubber hoses are used extensively in automotive construction. They carry air (vacuum) pressure, coolant, air conditioning refrigerant, fuel, lubricant, and various types of fluids, such as brake and power-steering fluids. These varied applications require different designs in hoses. Some hoses must withstand high temperatures, while others are subjected to extreme cold. Some must be able to hold liquids or gases that push outward with high pressure, while others must keep from collapsing due to the low pressures inside them. Some hoses must transport large volumes of substances quickly, while others must actually restrict the flow of substances they carry. Some hoses can perform their function correctly only if they remain flexible, while others must be almost as rigid as pipe.

These requirements show how important it is that the automotive service specialist be able to select proper hoses for the varied purposes they serve. This supplement will help familiarize you with considerations in selecting automotive hoses.

HOSE CONSTRUCTION

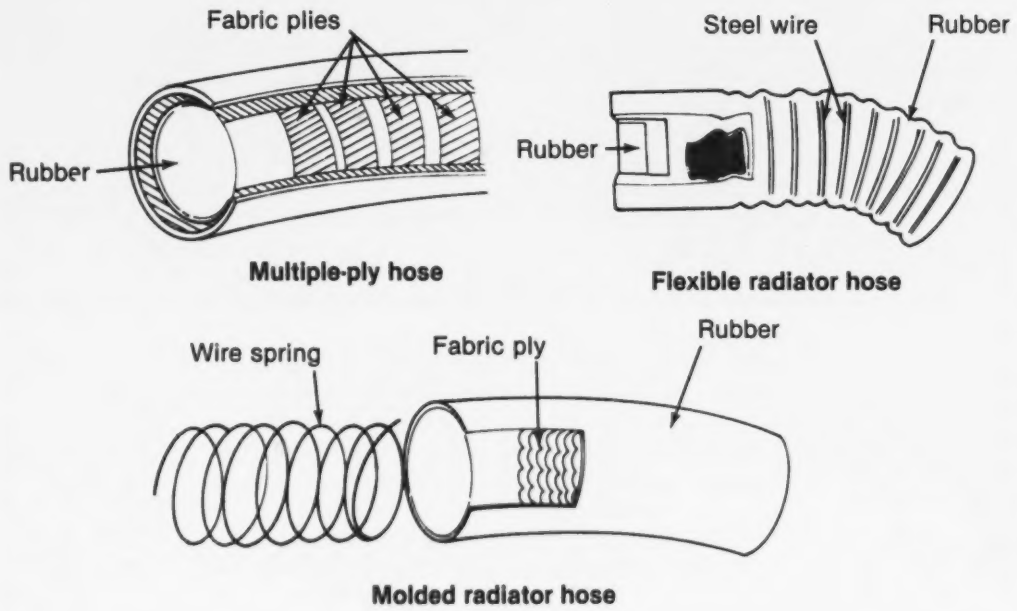
Automotive hoses are made of rubber but are often reinforced with other materials and may contain more than one type of rubber. Reinforcing materials include metal or cloth fabric, metal or plastic mesh, nylon or rayon braiding, and steel wire.

The materials used and the number of layers will depend on the substance to be carried, its temperature, and its pressure, including required changes in temperature and pressure. For example, brake system pressures may reach 1,000 pounds per square inch (psi). To give you some idea of how much pressure this is, consider that the pressure of the air around you is approximately 15 psi, that a typical tire inflation level is 30 psi, and that the air compressor in your shop probably develops no more than 300 psi. In other words, a brake system hose may have to withstand pressures more than three times greater than that produced by your shop air compressor.

For this reason, hoses for pressurized systems often use many layers of rubber and reinforcement. Each layer is called a *ply*. The illustrations in Figure 1 on the following page show the plies used in several types of hoses.

810

FIGURE 1



From *Introduction to Automotive Mechanics Unit I: Hand Tools, Automotive Fasteners, Shop Equipment and Supplies*, rev. ed., © 1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

HOSE SHAPES

One of the main reasons for using rubber hose in automotive construction is because it is flexible. *Flexibility* is the ability of a substance to bend and change shape again and again while maintaining enough of its original shape to be able to continue to serve its functions. Automotive hoses must be flexible because the movement of the vehicle shifts automotive components in relationship to each other. If hoses did not flex, they would break or bend and close off the opening inside them.

In some installations, however, it is desirable to limit the amount of flexibility in a hose. For this reasons, three designs of hoses are used. Soft rubber hoses are highly flexible. Unpressurized fuel hose and most nonreinforced hoses, such as that used for vacuum lines, are of this type. *Accordion hose* has limited flexibility but will bend easily. It is often reinforced with wire or spring coils. *Molded hoses* have little flexibility and will return to their molded shape if bent and released. They are generally made of harder rubbers with heavier fabric reinforcement than other types of hoses. These last two types are shown in Figure 1.

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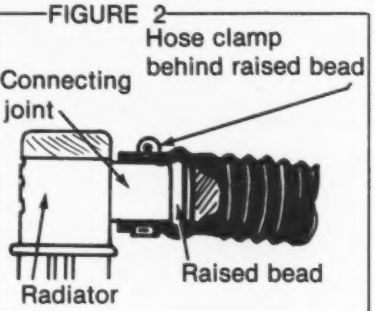
HOSE FASTENERS

The varied uses of hoses and installation requirements have led to a number of ways of securing hoses at their connections. The simplest method is that the hose just slips over a tube. The tube may have a raised bead or ridge around it, but the fit between the hose and the tube is enough to hold the hose in place. This connection is used with soft rubber hoses where little pressure is developed, such as in vacuum lines and the windshield washer system.

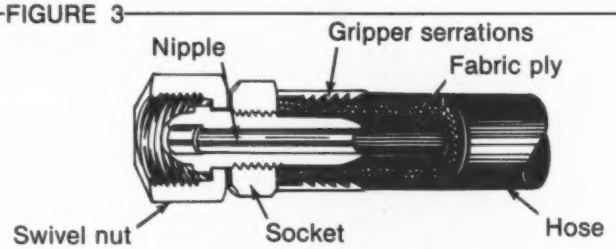
Other hoses are normally clamped at their connections. These hoses may use any of the clamps that you have studied, including crimp, wire, wormdrive, and band clamps. These connections are normally made so that the fastener is positioned behind a raised bead as illustrated in Figure 2 below.

FIGURE 2

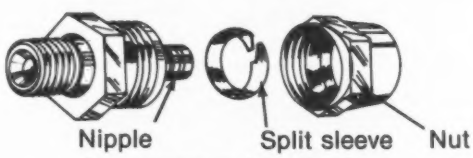


Hoses are also used with threaded couplings or are designed to have threaded fasteners installed. A variety of reusable hose ends are available. Most come with instructions for installation because attachment procedures vary greatly. A typical high-pressure design and a typical low-pressure design are shown in Figure 3.

FIGURE 3



High-pressure hose end



Low-pressure hose end

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SUPPLEMENT 3

Shock Absorbers

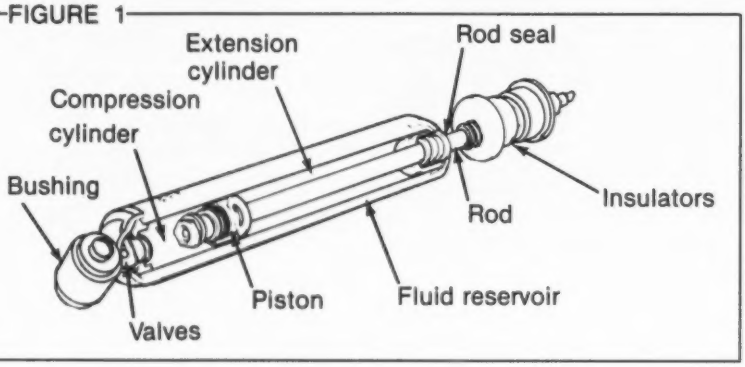
INTRODUCTION

The purpose of shock absorbers is to slow the effects of a vehicle driving over uneven surfaces. If vehicles were not equipped with shock absorbers, a vehicle would continue bouncing after each bump in the road. This would not only be uncomfortable for those riding in the vehicle, but it would also make it difficult for the driver to maintain control of the vehicle.

SHOCK ABSORBER DESIGN

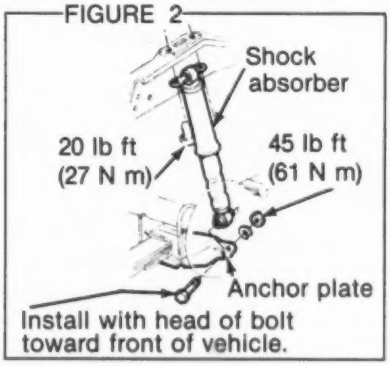
A shock absorber is basically a tube, called a *cylinder*, filled with oil. A rod extends from one end of the cylinder. The end of the rod inside the cylinder has a disc just slightly smaller than the diameter of the cylinder. The disc is called a *piston*. These parts and others are shown in Figure 1.

FIGURE 1



Used with permission of Ford Motor Company.

FIGURE 2



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

The end of the rod that extends from the cylinder and the other end of the cylinder are attached to the vehicle. One end is connected to a rigid part of the vehicle frame or body while the other end is connected to a movable part of the wheel and axle assembly, such as the lower control arm. A typical installation is shown in Figure 2.

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SHOCK ABSORBER OPERATION

The shock absorber performs its function by the movement of the piston in the cylinder. When a vehicle hits a bump, the wheel is forced up, causing the shock absorber rod to compress into the cylinder. The oil resists the movement of the piston so that the effects of the bounce are softened. The return of the wheel to its normal position after the bounce is also slowed as the piston movement is resisted by the oil. The slowed up-and-down motion of the piston lessens the reaction of the vehicle-to-surface unevenness.

TYPES OF SHOCK ABSORBERS

The shock absorbers discussed to this point are known as *conventional* shock absorbers. Conventional shock absorbers generally come in normal and heavy-duty designs. Heavy-duty shocks are usually even slower reacting than normal shocks. In most cases, heavy-duty shocks have a larger cylinder diameter.

Designs of shock absorbers other than conventional types include:

Gas-charged shock absorbers, which contain a gas such as hydrogen in the cylinder. The gas keeps the oil under pressure which reduces the formation of bubbles in the oil as the piston moves in the cylinder. Bubbles lessen the effectiveness of the oil in resisting piston movement.

Adjustable shock absorbers, which provide a means for the stiffness of the shock to be changed. This is normally done by turning a knob or the body of the shock to change the opening of the valve in the cylinder or the pressure of gas.

Self-leveling shock absorbers, which are designed to help maintain the vehicle at a certain height at each wheel.

These designs often come in normal and heavy-duty versions and often are combinations of each other, such as gas-charged adjustable shocks or gas-charged self-leveling shocks.

In Job Sheet 6, you will learn how to inspect and replace conventional shock absorbers.

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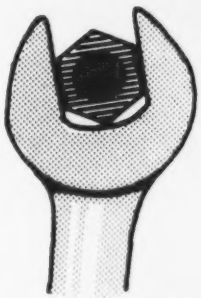
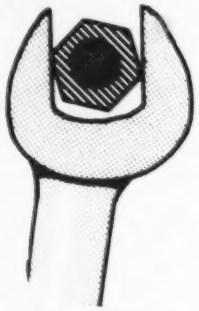
Right and Wrong Uses of a Wrench



Right—Use a wrench that fits the nut or bolt you are working on.



Wrong—*Never* use a wrench that is too large for the nut or bolt you are working on.

Right—Pull, do not push, when using a wrench.

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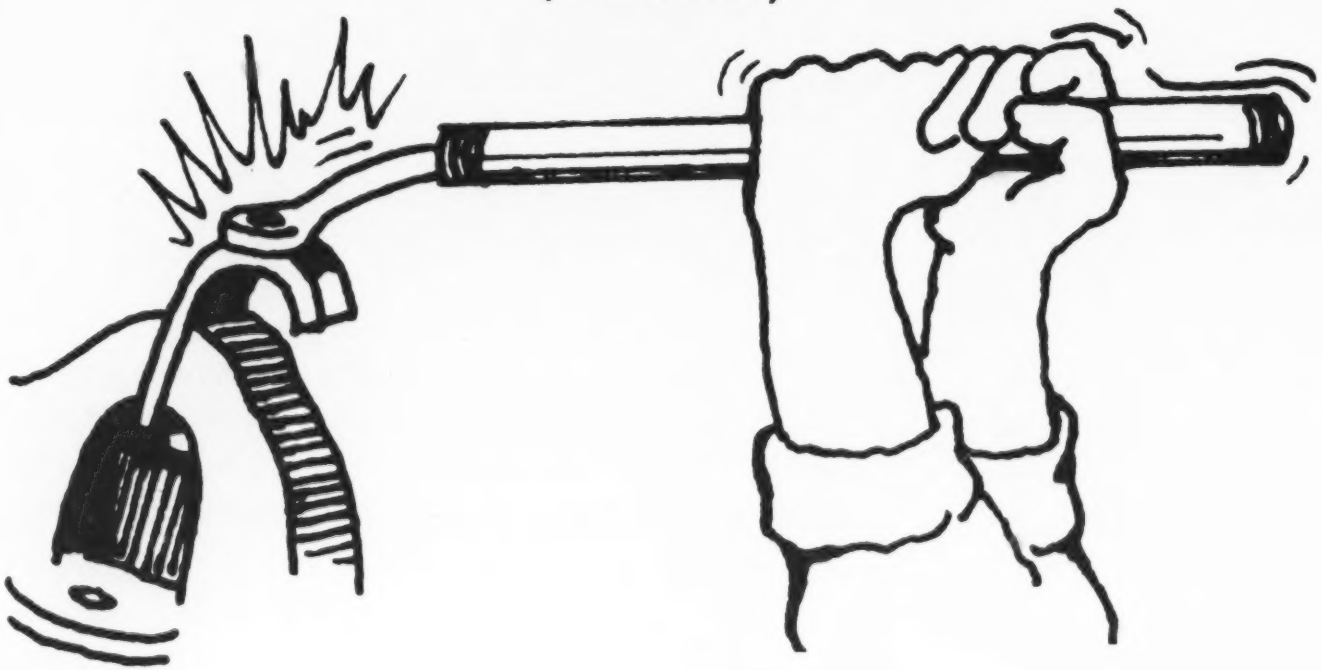
Right and Wrong Uses of a Wrench
(Continued)



Wrong—*Never* use a bar or a pipe to extend the wrench handle. The extra force may bend or break the wrench.

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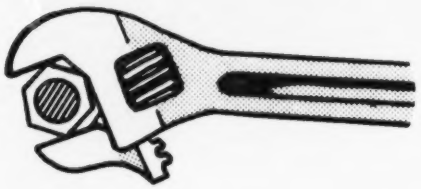
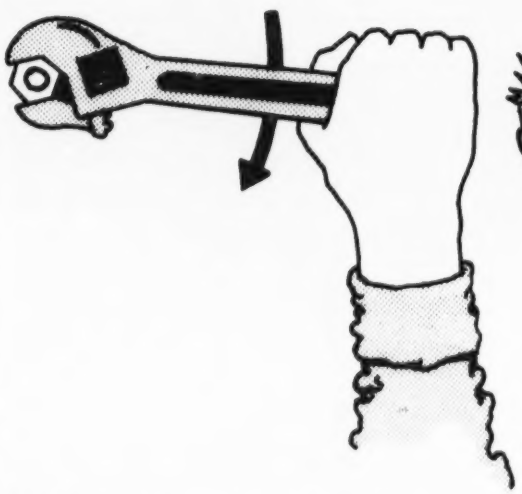
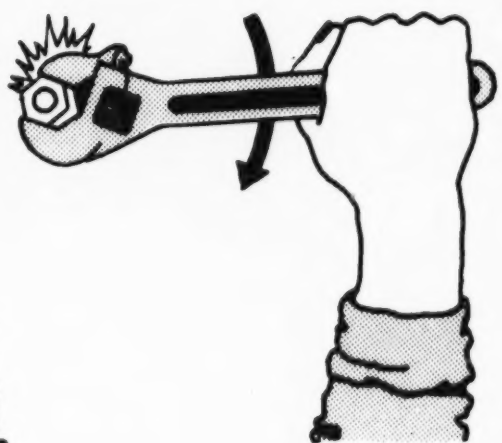
Right and Wrong Uses of a Wrench
(Continued)



Wrong—*Never* pull on an adjustable wrench until it has been tightened on the nut.



Right—When using an adjustable wrench, exert force against the large jaw.



Wrong—*Never* exert force against the small jaw of an adjustable wrench.

PRETEST ANSWERS

REMOVE AND INSTALL COMMON FASTENERS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 9, 20
2	6, 36
3	2, 13, 25, 27, 28, 29, 39
4	33, 34, 41
5	16, 21, 30
6	4, 15, 32
7	7, 11, 22, 31
8	8, 14, 35
9	3, 18, 43
10	10, 23
11	19, 38
12	5, 40
13	12, 37
14	17, 42
15	24, 26

ANSWER KEY

1. b
2. a
3. d
4. a
5. d
6. c
7. c
8. c
9. b
10. c
11. b
12. c
13. a
14. a
15. d
16. b
17. c
18. d
19. a
20. a
21. b
22. b
23. b
24. c
25. d
26. d
27. a
28. b
29. d
30. a
31. d
32. a
33. d
34. b
35. c
36. b
37. a
38. c
39. c
40. d
41. b
42. d
43. c

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PRETEST

REMOVE AND INSTALL COMMON FASTENERS

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. The best definition of *fastener* is

   a. Tool used to remove or install holding devices
   b. Device or substance used to hold parts together
   c. Automotive part designed to restrict movement of components and assemblies
   d. Device used to remove unwanted materials from a substance that moves through it

2. Which of the following is a locking washer?

   a.

   b.

   c. Both a and b
   d. Neither a nor b

3. Which of the following materials may be used in automotive air filters?

   a. Paper
   b. Cellulose fiber
   c. Polyurethane foam
   d. All of the above

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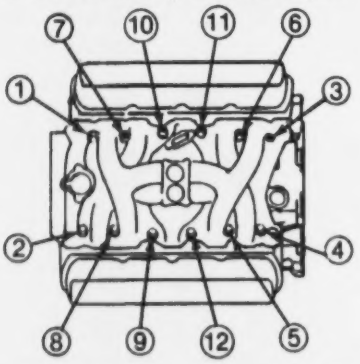
4. The following illustration shows the intake manifold bolt-tightening sequence. When tightening these bolts, where should the service specialist begin?



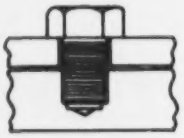
Used with permission of General Motors Corporation, Oldsmobile Division.

a. At the left end
b. At the right end
c. In the middle
d. At either end

5. When removing and reinstalling a tire-and-wheel assembly,

a. Loosen lug nuts or bolts a few turns before raising vehicle
b. Inspect the lug fastener threads
c. Use wrench of correct size to remove and install lug nuts
d. All of the above

6. Which method of holding threaded fasteners is illustrated below?



a. With other fasteners
b. With a hole tapped into a cast nut
c. With a hole tapped into a solid part
d. None of the above

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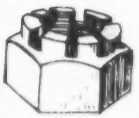
7. You are going to use the fastener illustrated at the right, a castellated nut, on a part that is subject to vibration. Which of the following fasteners shown below is used to complete the installation of this nut?



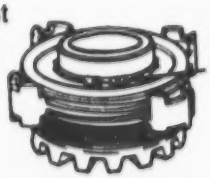
a.

b.

c.

d.

8. Which of the tools below is best suited to remove the snap ring shown in the illustration at the right?



Copyright 1985, General Motors Corporation.

a.

b.

c.

d.

9. Which of the following is the best definition of *PCV valve*?

   a. Device used to control the flow of lubricant to the pumping velocity chamber
   b. One of several automotive devices used to prevent harmful substances produced during engine operation from entering the air
   c. Device used to join tubing and hoses
   d. Device used to remove unwanted materials from a substance that moves through it

10. An important function of the positive crankcase ventilation (PCV) valve is to

   a. Adjust the flow of air through the system for various engine operating conditions
   b. Prevent engine blowby fumes in the crankcase from igniting
   c. Both a and b
   d. None of the above

11. One type of nonthreaded fastener fits into a groove on the inside or outside of a shaft and prevents another part from moving along this shaft. What is this type of nonthreaded fastener called?

   a. Clamp
   b. Snap ring
   c. Woodruff key
   d. Clip

12. An important guidelines to observe when replacing hoses is to

   a. Be sure that any band or worm-drive clamps are as tight as they can possibly be to avoid leaks
   b. Never check connections with the system operating
   c. Use replacement hose with standards meeting or exceeding those of the original hose
   d. Never reuse a worm-drive or band clamp

13. Which of the following fasteners is metric?

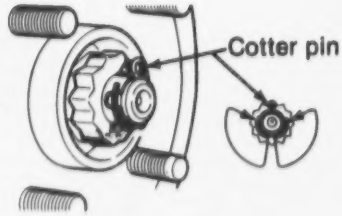
a.

b.

c.

d.

14. You need to remove the cotter pin from the installation shown at the right. Which of the tools below is best suited for removing the cotter pin?



Used with permission of Chrysler Corporation.

a.

b.

c.

d.

15. When installing a threaded fastener, the service specialist may need to refer to the service manual to find information about which of the following?

a. Torquing requirements
b. Tightening sequence
c. Grade of fastener to be used
d. All of the above

16. Study the fastener show at the right. Which of the tools shown below would be best suited to install the fastener?

a.

b.

c.

d.

17. Shock absorbers do **not** need to be replaced if

    a. The dust shield is damaged
    b. The pressure tube is worn
    c. The mounting hardware is loose but undamaged
    d. The hydraulic fluid has drained from the shock absorber due to a poor seal

18. When cleaning or inspecting an air filter, you should always

    a. Used compressed air to clean the filter
    b. Use a solution of soapy water to clean the filter
    c. Clean filter housing by soaking it in cleaning solvent
    d. Check gaskets to be sure that they are in good condition and make an airtight seal

19. When changing a fuel filter,

    a. Use tubing wrenches to disconnect and connect fuel lines
    b. Allow any excess fuel to drain from lines onto floor before installing new filter
    c. No special procedures are necessary if system is a fuel-injection system
    d. Make note of any fuel leaks in the system, so leaks can be repaired at a later date

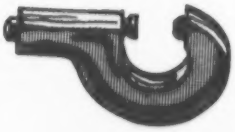
20. Which of the following is the best definition of *filter*?

a. Device used to remove unwanted materials from a substance that moves through it
b. Device used to increase airflow around the engine for improved cooling
c. Device with a wide opening at one end and a narrow opening at the other end used to help pour substances from their containers into other containers
d. Device used with fasteners to improve hold

21. Which of the tools shown below is best suited to remove a nut that has rusted in place?

a.

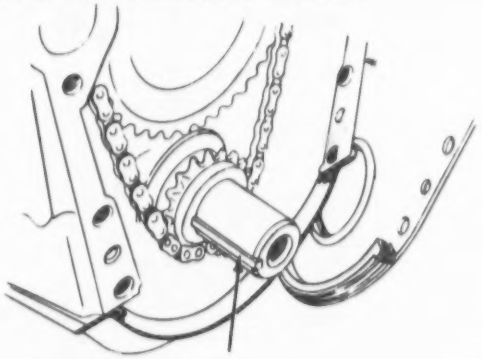
b.



c.

d.

22. In the illustration below the nonthreaded fastener indicated with an arrow is used to hold a shaft in place. What is the name of this nonthreaded fastener?



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a. Roll pin
b. Key
c. Clip
d. Rivet

23. An inspection of the PCV system should include

a. Cleaning the system using compressed air
b. Testing the PCV valve operation
c. Repairing any defective parts in the PCV valve
d. Inspecting the oil filter

24. Specialist A says that if the headlights of a vehicle are aimed too high, the driver will not be able to see what lies just ahead of the vehicle. Specialist B says that if the headlights point too far to the left, they may blind oncoming drivers.

Who is correct?

a. Specialist A
b. Specialist B
c. Both A and B
d. Neither A nor B

25. Specialists A, B, and C are discussing the tensile strength of the three bolts illustrated below.

Bolt 1 Bolt 2 Bolt 3

Specialist A says that Bolt 1 has a greater tensile strength than Bolt 2. Specialist B says that Bolt 3 has a greater tensile strength than Bolt 2. Specialist C says that Bolt 2 has the least tensile strength of all three bolts.

Who is correct?

a. Specialist A
b. Specialist B
c. Specialist C
d. Specialists A, B, and C are all correct

26. When aiming headlights,

a. The vehicle must be standing on a level surface
b. The vehicle's headlights may be directed to a screen with vertical and horizontal markings
c. A mechanical aimer may be attached to each headlight
d. Any of the above may be true, depending on the method used

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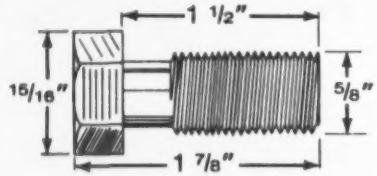
NOTE: For questions 27 through 29 refer to the illustration and description below.



5/8 – 18 UNF – 2A x 1 1/2

27. What is the diameter of this fastener?

a. 5/8"
b. 15/16"
c. 1/2"
d. 1/16"

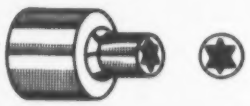
28. What is the length of this fastener?

a. 1 7/8"
b. 1 1/2"
c. 18 mm
d. 5/8"

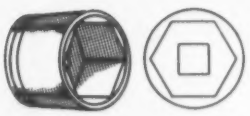
29. Which of the following statements about this fastener is true?

a. The fastener has coarse threads
b. The fastener is a metric fastener
c. The fastener has 20 threads per inch
d. The fastener has fine threads

30. You must install the fastener illustrated at the right. Which of the following tools would be best suited for installing this fastener?

a. 

b.

c. 

d.

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31. Some parts are held in place by using one type of nonthreaded fastener that is inserted through holes in these parts. Which of the following fasteners can be used in such a way?

    a. Cotter pin
    b. Roll pin
    c. Spring pin
    d. All of the above

32. Which of the following is **not** a guideline about the use of threaded fasteners?

    a. Never reuse a threaded fastener
    b. Always hand-start fastener
    c. Follow manufacturer's instructions regarding torque and sequence
    d. Clean and inspect threads before reusing a threaded fastener

33. You must replace a broken stud. The end of the broken stud is shown at the right. Which of the following studs could be used to replace this stud?

    a.

    b.

    c.

    d. Either a or c

34. The fastener at the right must be replaced due to damaged threads. Which of the fasteners below would be a suitable substitute?

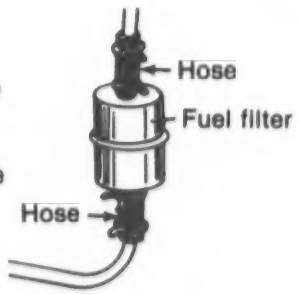
a.

b.

c.

d.

35. In the illustration at the right, nonthreaded fasteners are used to attach the fuel filter to hoses. Which of the following tools is best suited to use to remove these fasteners?



Adapted with permission of Chrysler Corporation.

a.

b.

c.

d.

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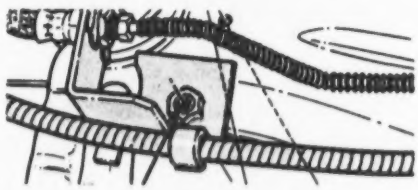
36. The illustration below shows one method for holding threaded fasteners. What is this method?



Adapted with permission of Chrysler Corporation.

a. With other fasteners
b. With hole tapped into cast nut
c. With hole tapped into solid part
d. With a self-tapped hole

37. When inspecting hoses,

a. Check for cracks or splits near connections
b. Do **not** squeeze hose as this may loosen connection
c. Clamp one end of the hose and fill with compressed air to check for leaks
d. Do **not** inspect hoses; replace them with any service

38. All of the following may be indications of a clogged fuel filter **except**

a. Engine stops
b. Engine shutdown during heavy acceleration
c. Fuel tank not receiving fuel
d. Engine runs roughly

39. Which of the following statements is **not** true?

a. A self-tapping screw cuts its own threads as it is screwed into a soft material
b. A set screw is used to hold parts in place on rotating surfaces
c. A wing nut is used as a decorative fastener to cover bolt ends or threaded studs
d. A square nut is used where secure fit is not critical

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40. Which of the following statements about tightening lug fasteners when installing a tire-and-wheel assembly is true?

a. Each fastener should be tightened to required torque, following no designated sequence
b. Before lowering the vehicle, each fastener should be started, but wheel should not be snug against hub
c. After lowering the vehicle, each fastener should be started and then tightened to required torque
d. None of the above

41. You need to mount a piece of molding to the plastic surface of an interior door panel. Which of the following fasteners is best suited for this installation?

a. Stud
b. Self-tapping screw
c. Machine screw
d. Cap screw

42. Specialist A says that shock absorbers must usually be replaced in pairs, except in certain situations on very low-mileage vehicles. Specialist B says that failure to replace both front shocks or both rear shocks together can lead to an uneven ride and possibly to dangerous differences in the side-to-side handling of the vehicle.

Who is correct?

a. Specialist A
b. Specialist B
c. Specialist A only if the vehicle is equipped with McPherson struts
d. Both A and B

43. Which of the following statements is **not** correct concerning the care of air filters?

a. Air filters must be cleaned or replaced when they become clogged with particles to the point that not enough air gets through to mix with the fuel
b. The need for cleaning and replacement of an air filter depends on factors such as how the vehicle is driven and the roads over which it is driven
c. Vehicle manufacturers do **not** recommend cleaning or changing intervals for air filters
d. Air filter designs vary for different makes and models of vehicles

INFORMATION SHEET

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 1

Recognize definitions of terms associated with common fasteners

Fastener — Device or substance used to hold parts together

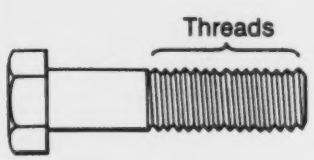
EXAMPLES: Bolts, screws, clips, glue

Threaded — Having a raised, spiral ridge designed to match a similar ridge in another part to form a secure hold (Figure 1)

NOTE: External threads are made by using a tool called a *die*; internal threads are made by using a tool called a *tap*.

EXAMPLE:

FIGURE 1



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Tapped hole — Hole in which threads have been cut

Filter — Device used to remove unwanted materials from a substance that moves through it

EXAMPLES: Air filter, fuel filter, oil filter

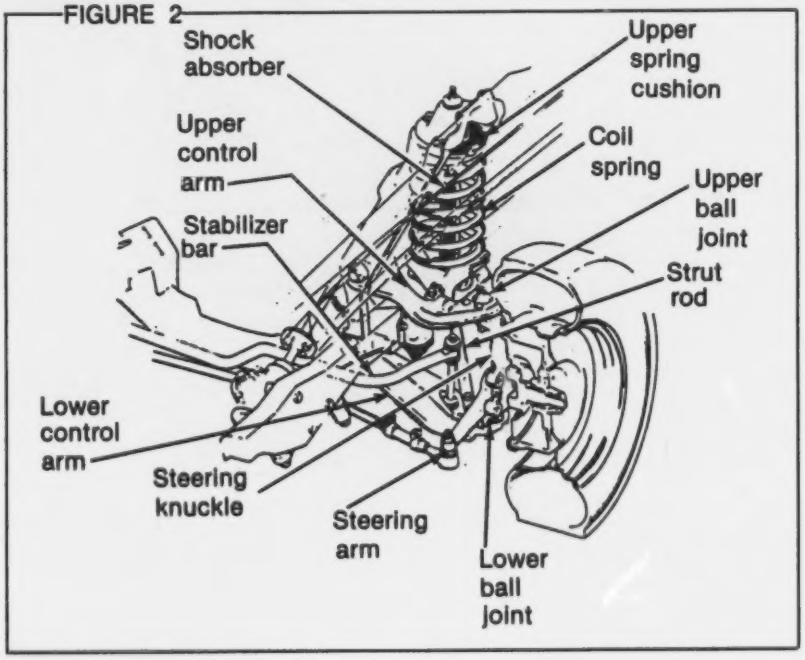
PCV valve — One of several automotive devices used to prevent harmful substances produced during engine operation from entering the air

Hose — Hollow, generally rubber device used to direct substances from one place to another in automotive systems

Shock absorber — Part of the suspension system on many vehicles; used to reduce the amount of vibration caused by traveling over uneven surfaces (Figure 2)

EXAMPLE:

FIGURE 2



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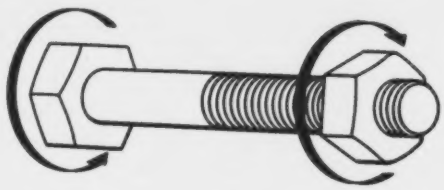
OBJECTIVE 2

Recall methods for holding threaded fasteners

- With other fasteners

FIGURE 3



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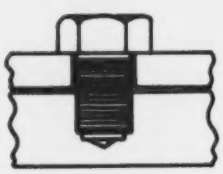
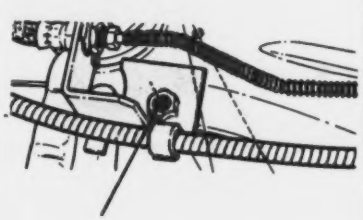
- With hole tapped into a solid part

FIGURE 4



- With hole tapped into a cast nut

FIGURE 5



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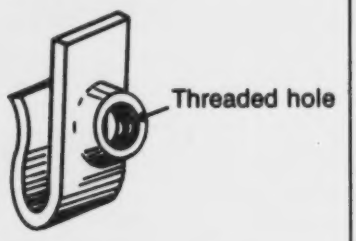
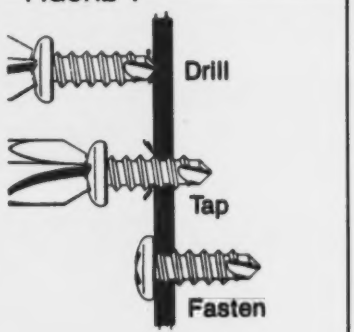
- With a threaded clip

FIGURE 6



- With a self-tapped hole

FIGURE 7



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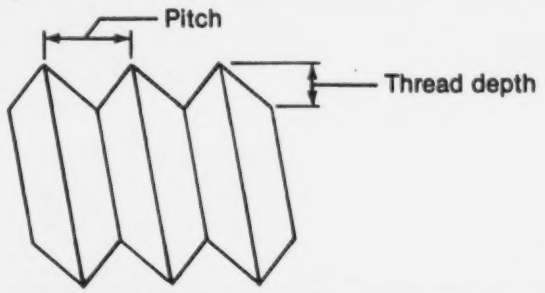
REMOVE AND INSTALL COMMON FASTENERS

SUPPLEMENT 1

Threaded Fasteners

A thread is that raised ridge that runs around such fasteners as screws and bolts and inside nuts. Threads are what give such fasteners their holding power, like interlocked fingers. Threaded designs vary to suit different purposes. This variation is most likely in two characteristics of the thread: pitch and depth.

FIGURE 1



Pitch is the distance between two threads. Actually, because there is really only one thread running in a continuous spiral around a fastener, pitch is the distance between two similar points on the thread along a line that is parallel to the center line of the fastener. But for practical purposes it is simpler to speak of such points as threads. In fact, pitch is normally measured as *threads per inch* for threads using U.S. customary measurements and in *millimeters between threads* for metric fasteners.

Thread depth is the measure of how far the notch between threads is cut into the fastener. Pitch and thread depth vary from one fastener to another, depending on the fastener's intended use. For example, one type of screw is called *self-tapping* and is designed to cut its own holding thread as it is screwed into a soft material, such as the screws that hold some plastic moldings in vehicle interiors. Such screws have a relatively deep thread depth and a relatively long pitch. This design allows the screw to cut a deep, securing thread, while the space between the threads ensures that there will be sufficient material left to make the securing threads strong.

Machine screws, on the other hand, have relatively shallow threads and a short pitch to give more threads per inch. This design provides a tight fit and is useful where parts must be well-sealed with small fasteners, such as the parts of a carburetor housing.

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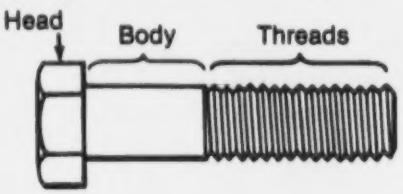
Thread depths and pitches have become standardized over the years. The majority of threaded fasteners are made with what is termed a *coarse thread*, while some fasteners have *fine threads*. Coarse threads are cut deeper than fine threads and have a wider pitch. For example, a coarse-threaded bolt one-half inch in diameter has 13 threads per inch. A fine-threaded bolt of the same size has 20 threads per inch. These standards are used in identifying fasteners, as you will study in Objective 3.

SCREWS AND BOLTS

The size of a fastener is also used in its identification. To understand how fasteners are measured, you must first become familiar with the parts common to most threaded fasteners. Although terms may vary, the illustration below shows the names of some of the more important parts of a bolt or screw.

FIGURE 2



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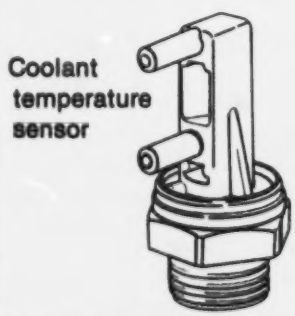
Bolts and screws are the two major types of threaded fasteners. Some bolts and screws are so similar that the only real difference is in how they are used. Screws go into a threaded part or make their own threads, while bolts are used with nuts.

Table 1 on the following pages describes the threaded fasteners that are most commonly used for automotive applications.

One step more . . .



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In addition to the various types of threaded fasteners that are used to hold vehicle parts together, some automotive parts are threaded to fit into other parts. One threaded part with which you may be familiar is the *spark plug*. The electrode end of a spark plug is mounted in a threaded housing that fits a threaded hole in the engine block. Similarly, many drain plugs, including oil pan drain plugs, are threaded. Various sensing devices, such as coolant temperature and oil pressure sensors, may be threaded. Most radiators are equipped with a special plug called a *petcock* that is threaded and can be opened to drain the coolant. What others can you think of? Check a service manual and make a list of some of the threaded parts that you find mentioned.

TABLE 1: Types of threaded fasteners and their uses

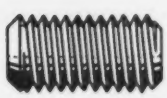
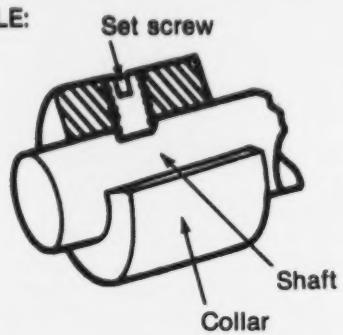
Type	Use
Cap screw	Used extensively in automotive construction, especially for mounting parts or components to large surfaces that can be threaded. For example, in many vehicles most of the parts attached to the engine block are held by cap screws: head, oil pan, thermostat housing, fuel pump, manifolds, and brackets for power steering pump, air conditioner, emission controls, and other components.
Machine screw	Used for essentially the same purpose as cap screws but generally for smaller parts or where the threaded hole into which the screw fits has thin walls. Common examples of the use of machine screws include assembly of the carburetor, cranking motor, and distributor; securing of certain electrical connections; and special applications such as engine idle speed adjustment screws.
Metal screw	Used to hold parts attached to thin metal, such as body panels, where tight fit is not critical. Examples include mounting splash guards, voltage regulators, computer command modules, fuse blocks, and other parts.
Self-tapping screw	Used to mount parts to soft metal or plastic surfaces. Moldings, clothes hooks, dash components, and securing strips are held in place by self-tapping screws. **NOTE:** A self tapping screw is similar to a metal screw but generally has a special tip and thread that permits it to cut its own thread into a surface.
Set screw 	Used to hold parts in place on rotating surfaces, such as shafts. Common uses include securing the drive gear on the oil pump shaft and mounting the hub on the water pump shaft. EXAMPLE: 

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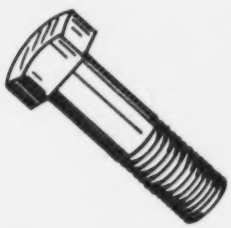
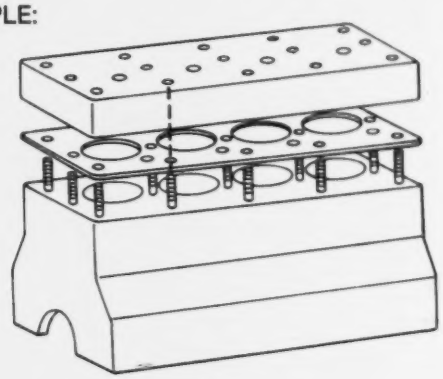
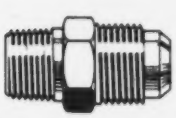
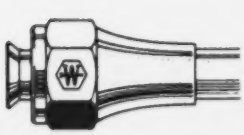
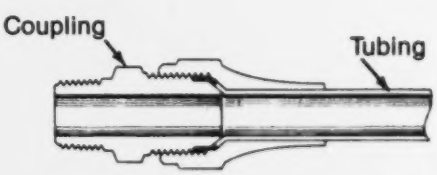
TABLE 1 (continued)

Type	Use
Hex bolt 	Used in much the same way as a cap screw is used but is secured with a nut. Hex bolts are often used to hold together suspension and steering linkages, to secure shock absorbers, to tighten battery clamps, and to hold components in place along adjustment slots. **NOTE:** Cap screws over an inch or so long are often referred to as bolts even though they are threaded into a part. For example, the cap screws that hold the cylinder head to an engine block are generally called *head bolts*.
Stud 	Used where it might be difficult to align a screw or bolt with a hole, such as a large part with several fasteners and a gasket. **NOTE:** Studs normally have coarse threads on one end and fine threads on the other, and they do not have a head. EXAMPLE:  Reproduced by permission of Deere and Company, ©1987 Deere & Company. All rights reserved.
Coupling  	Used to join tubes or hoses to each other or to other components. EXAMPLE:  Used with permission of Weatherhead Div., Dana Corp.

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NUTS

Nuts are used to secure bolts, on studs, and on other threaded parts, such as wheel spindles. Nuts come in a variety of designs and sizes. Sizes and threading vary to match the bolt or threaded part with which the nut is to be used. Designs vary to suit the needs of specific applications.

Within the variety of designs, however, there are two major classifications of nuts: *standard* and *locking*. Table 2 on the next page describes standard nuts commonly used in automotive construction. Locking nuts are generally just variations of a *hex nut*. Nuts are locking nuts when some feature of their design reduces the chances of the nut coming loose due to vibration or contact with moving parts. Three of the most common locking nut designs are shown in Figure 3.

FIGURE 3

How Many Times Can You Use a Nut?

Nuts, bolts, and some other fasteners may be considered hard or soft. The softer that a fastener is the sooner it loses its strength through reuse. Generally, nuts are softer than bolts on which they are intended to be used. This is done so that the nut will mold itself to fit the bolt better, thus spreading the stress of holding the parts together throughout the nut. One study showed that a nut may loose one-fifth of its strength the first time time it is used. After the second use, a third of its strength is gone. By the fifth time the nut is used, almost half its holding power has been lost. With each reuse, the nut weakens even more. This loss of strength in metal is called *fatigue*, and some experts think that 75 percent of all fastener failures result from fatigue. So, how many times can you use a nut? For greatest strength, only once. This is especially true of distorted-thread and insert locking nuts because they quickly lose their locking power. Other nuts can probably be used several times without too much worry *if* some simple guidelines are followed. Clean the threads. Do not force threaded fasteners together. Do not overtighten fasteners, and use good-quality fasteners to begin with.

The *self-locking* type has a built-in washer. (See the following section on washers.) The *distorted-thread* type uses a cut slot or other method of changing the angle of the thread, while the *insert* type has a soft—usually plastic—insert into which threads are cut when the nut is installed. Locking nuts are frequently used on engine mounts, shock absorbers, rocker arm studs, and suspension struts.

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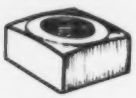
TABLE 2: Types of standard nuts and their uses

Type	Use
Hex	Most commonly used nut; provides good fit for tools used to tighten and remove nuts. Used with bolts, threaded studs, and threaded parts.
Square 	Used where secure fit is not critical, such as where there is little vibration or working forces, or where the fit or design of parts permits tightening of the bolt through contact between the nut and a part. Square nuts or square-head bolts are commonly used on battery cable terminals.
Slotted or **Castellated**	Used with a cotter pin or other holding device so that the nut will not come off a threaded shaft. A hole in the shaft allows a pin to be inserted through the shaft and aligned with the slots in the nut. Once the pin is in place, the nut cannot turn. Used where rotation or vibration can quickly loosen a nut, such as on wheel spindles, tie-rod ends, and ball joints.
Wing	Used as a fastener where easy removal without tools is desired, such as for a jack or spare tire hold-down or air filter cover fastener.
Speed	Used for factory installation of some components. Speed nuts slip over threaded studs, such as wheel lugs to hold brake drums or rotors in place or to fasten such parts as radiator shrouds.
Acorn (cap)	Used as a decorative or protective fastener to cover bolt ends and threaded studs. Often treated with a chrome finish to improve appearance. May be used for customizing vehicles, such as on valve covers and air filter covers.

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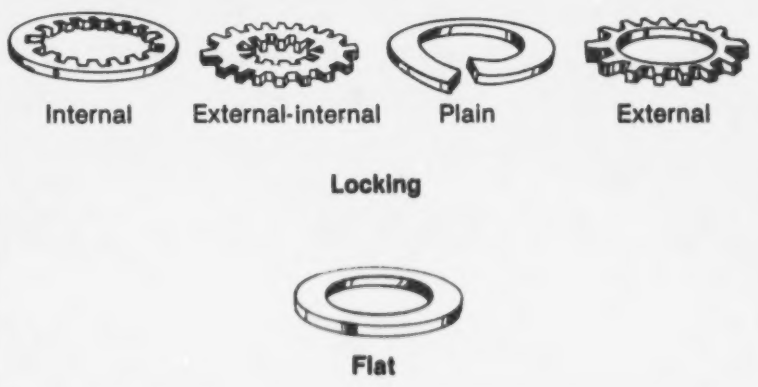
WASHERS

The holding power of threaded fasteners comes from pressure between the threads of the fasteners and also from the pressure placed on the parts being held. To increase or to spread out this pressure, washers are used. A washer is simply a ring or circle, usually made of metal, slightly larger than the nut or bolt head with which it is used and containing a hole slightly larger than the bolt diameter. The bolt goes through the hole so that the washer is between the screw head and the part for a tapped hole or between the nut and the part. Some common designs used in the automotive trade are shown in Figure 4 below. *Flat washers* spread the pressure between the fastener and the part over a greater surface area, allowing a tighter fit without straining the fastener. *Locking washers* apply pressure against the fastener to help keep it from working out of the holding threads.

FIGURE 4



As you can see, there are a number of fastener designs with a variety of uses. You will learn more about fasteners and how they are used as you continue your studies of automotive service.

REMOVE AND INSTALL COMMON FASTENERS

SUPPLEMENT 2

Characteristics of Threaded Fasteners

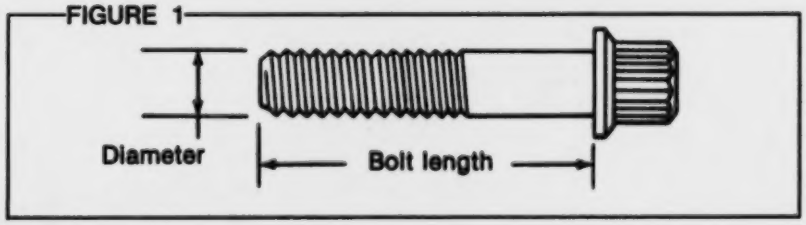
Fasteners come in many shapes and sizes for varied uses. But these various designs follow certain patterns. In this supplement you will learn about ways in which threaded fasteners are classified. These characteristics are things that the service specialist must consider when working with fasteners. Generally, you will simply use a fastener with the same characteristics as the one you removed. However, sometimes you may have to modify an installation. In such cases, the information below will be very helpful.

Measurement system — Unit of measurement used in describing fastener dimensions such as length, diameter, and threads per length. Automotive fasteners are usually measured in inches (U.S. Customary System) or in millimeters (metric system).

Thread pitch — Description of the design of threads, their depth, and their number per unit of measure. Automotive fasteners are generally labeled as either *fine* or *coarse*. Fine pitches have more threads per unit of measure than coarse pitches. Most threaded fasteners used in automotive construction have a coarse pitch.

Size — The diameter of the threaded portion and the length of the shaft for bolts and screws. Length is measured from the underside of the head to the end of the tip. Diameter is measured across the shaft at the base of the head (Figure 1).

FIGURE 1



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Tensile strength (grade) — A measure of how much a metal fastener will stretch without breaking. Tensile strength is stated as a measure of breaking point, such as 50,000 pounds of pressure. Grade is given as a number, such as 8; the higher the grade number, the higher the tensile strength. When choosing a replacement fastener, always choose one with a tensile strength the same as or greater than the tensile strength of the original fastener.

Material — Although most fasteners are made of steel, other materials may be used. As manufacturers began making lighter vehicles to improve fuel efficiency, more and more plastic fasteners appeared for low-stress installations. Brass or aluminum fasteners are sometimes used where the fastener is likely to be exposed to water or some chemicals because of their higher resistance to rust and corrosion. Copper or brass fasteners are sometimes used in some electrical systems, especially when they form part of an electrical circuit.

Heat treatment — Fastener manufacturers use a process of heating and cooling a fastener to make it less brittle—that is, less likely to break. This process is called *heat treatment*. Some fasteners are heat-treated.

Design — Fasteners can also be classified by certain design features. Many of these you have studied already, such as what kind of fastener it is. Is this nut a hex nut or a wing nut? Does this screw have a standard slot or a Phillips slot? Most design features concern the shape of the fastener and the tool used to remove or install the fastener. Another important design feature is whether the threads go around the fastener in a clockwise or counterclockwise direction. Most threaded fasteners have clockwise (or right-hand) threads, but some are made with counterclockwise (or left-hand) threads.

Markings — Threaded fasteners are often marked to identify some of their characteristics. Tensile strength, for example, is often indicated by a number or marking on the fastener that represents the grade of the fastener. Most bolts used in automotive construction are U.S. customary grades 2, 5, 7, and 8 or metric grades 4.6, 4.8, 5.8, 8.8, 9.8, or 10.9. In both systems, the higher the number the greater the tensile strength. Metric bolts generally have the grade marked on the head. Some nuts are stamped with a grade number, and some nuts have dots which indicate the grade. However, the grades of most U.S. customary bolts are indicated by a set of raised lines or dashes on the head. Grade 2 bolts have no lines, while the other grades have two fewer lines than the indicated grade. Thus, a grade 8 bolt has six lines, a grade 7 bolt has five lines, and a grade 5 bolt has three lines. See Figure 2 on the following page to see these different markings.

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FIGURE 2

U.S. Customary System

- Bolts and cap screws

Grade 2 Grade 5 Grade 7 Grade 8

Grades indicated by marks on head

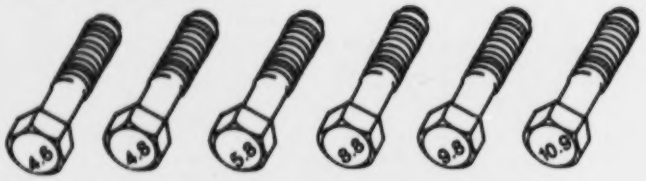
- Nuts

Grade 5 Grade 8

Grades indicated by dots

Metric

- Bolts and cap screws



Grades marked on fastener heads

- Nuts

Grades indicated by numbers

- Studs

Grades (for smaller studs) indicated with codes

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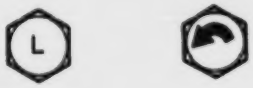
Fasteners may be marked to indicate their measurement system. Some bolts may have a dot of blue paint on their heads identifying them as metric. Figure 3 below shows a lug bolt marked with an *M* that indicates that it is a metric bolt.

FIGURE 3

Threaded fasteners may also be marked to indicate their thread direction. Left-hand threaded fasteners are usually marked with an *L* or with an arrow pointing counterclockwise as shown below in Figure 4.

FIGURE 4



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SUPPLEMENT 3

Threaded Fastener Sizes

The two important considerations in fastener size are the length and diameter of the fastener. Obviously, a screw must be the right diameter to fit the threaded hole in which it is installed or the right diameter to cut threads in a hole in the case of a self-tapping screw. A metal screw's diameter should fill the hole in which it is installed. Similarly, the diameter of a bolt should fit easily but snugly into the hole in which it is installed and the mating nut must be the right diameter to fit the bolt.

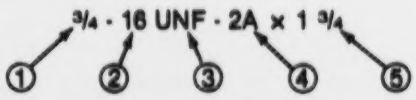
As you learned in Student Supplement 2, the diameter of threaded fasteners is determined by the width of the shaft at the base of the fastener head. It is important to remember this because some people get confused when they put a half-inch wrench on a half-inch cap screw and find that it does not fit. The size marking on the tool refers to the width of the fastener head, not the fastener size (diameter of shaft).

Length is measured from the base of the fastener head to the tip of the fastener. There are actually two aspects of length that are important when selecting threaded fasteners: the overall length of the fastener and the length of the threaded portion. While a bolt or screw may be several inches long, those used in automotive construction seldom have a threaded portion longer than two inches and usually much less.

Descriptions of bolts and screws are provided in designation numbers or descriptive symbols, such as ½ - 20 UNC - 2A × 3. This description provides size information concerning the bolt or screw: diameter, number of threads per inch, length, etc. The descriptions for U.S. customary and metric bolts and screws, however, are different. Study Figure 1 on the following page to see this difference and to see how these designation numbers are interpreted.

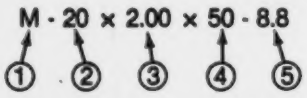
FIGURE 1

U.S. customary fastener descriptions



1 **Thread diameter (bolt size)** — This number may be a fraction or mixed fraction that indicates the diameter in inches or it may be a whole number, such as 1, 2, 3, etc., that is used to indicate size of a fastener with diameter of less than 1/4 inch
2 **Number of threads per inch**
3 **Thread type** — Coarse threads are indicated by UNC (Unified National Coarse) and fine are indicated by UNF (Unified National Fine)
4 **Fit symbol** — This is a thread class symbol which indicates manufacturing tolerances
5 **Length** — Length of bolt or screw is given in inches

Metric fastener descriptions



1 **M** — Indicates metric threads
2 **Thread diameter (bolt size)** — Given in millimeters
3 **Pitch** — Distance between threads in millimeters
4 **Length** — Given in millimeters
5 **Grade** — Indicates tensile strength

These metric and U.S. descriptions are used for both bolts and screws. Figure 2 shows some different bolts and screws with the interpretations of their designation numbers.

FIGURE 2

	Bolt	Cap screw	Self-tapping screw
	3/4 - 10 UNC - 2A x 2	M - 10 x 2.00 x 30 - 5.8	1/4 - 20 UNC - 2A x 1
Measurement system:	U.S.	Metric	U.S.
Diameter:	3/4 inch	10 mm	1/4 inch
Length:	2 inches	30 mm	1 inch
Threads/inch:	10	2.00 (pitch)	20
Fit:	2A	Not applicable	2A

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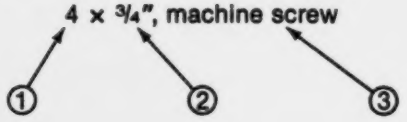
Another source that provides some of the same size information as the bolt or screw designation number is a *tap drill size chart.* Table 1 below is a tap drill size chart for common customary threads. This chart lists the size, threads per inch, and outside diameter of bolts and screws. It also tells the correct size of tap drill to use for the different diameters of screws and bolts. Notice that screws having a diameter less than 1/4 inch (.250 inch) are given numbers for sizes—0 through 10—rather than their actual diameter measurement as their size. For instance, a screw with a diameter of 1/8 inch (.125 inch) is listed as size 5.

TABLE 1: Common customary thread and tap drill size chart

National fine					National course				
Sizes	Threads per inch	Outside diameter at screw	Tap drill sizes	Decimal equivalent of drill	Sizes	Threads per inch	Outside diameter at screw	Tap drill sizes	Decimal equivalent of drill
0	80	.060	3/64	0.0469	1	64	.073	53	0.0595
1	72	.073	53	0.0595	2	56	.086	50	0.0700
2	64	.086	50	0.0700	3	48	.099	47	0.0785
3	56	.099	45	0.0820	4	40	.112	43	0.0890
4	48	.112	42	0.0935	5	40	.125	38	0.1015
5	44	.125	37	0.1040	6	32	.138	36	0.1065
6	40	.138	33	0.1130	8	32	.164	29	0.1360
8	36	.164	29	0.1360	10	24	.190	25	0.1495
10	32	.190	21	0.1590	12	24	.216	16	0.1770
12	28	.216	14	0.1820	1/4	20	.250	7	0.2010
1/4	28	.250	3	0.2130	5/16	18	.3125	F	0.2570
5/16	24	.3125	I	0.2720	3/8	16	.375	5/16	0.3125
3/8	24	.375	Q	0.3320	7/16	14	.4375	U	0.3680
7/16	20	.4375	25/64	0.3906	1/2	13	.500	27/64	0.4219
1/2	20	.500	29/64	0.4531	9/16	12	.5625	31/64	0.4843
9/16	18	.5625	0.5062	0.5062	5/8	11	.625	17/32	0.5312
5/8	18	.625	0.5687	0.5687	3/4	10	.750	21/32	0.6562
3/4	16	.750	11/16	0.6875	7/8	9	.875	49/64	0.7656
7/8	14	.875	0.8020	0.8020	1	8	1.000	7/8	0.875
1	14	1.000	0.9274	0.9274	1 1/8	7	1.125	63/64	0.9843
1 1/8	12	1.125	1 3/64	1.0468	1 1/4	7	1.250	1 7/64	1.1093
1 1/4	12	1.250	1 11/64	1.1718					

Another common notation used to describe screws gives the size and the length of the screw and usually the type of screw. This is shown in Figure 3 below.

FIGURE 3



1—Thread diameter (size)
2—Length
3—Type of screw

The screw described in Figure 3, therefore, is a size 4, is 3/4 inch in length, and is a machine screw. By referring to Table 1, you can see that a size 4 screw has a diameter of .112 inch.

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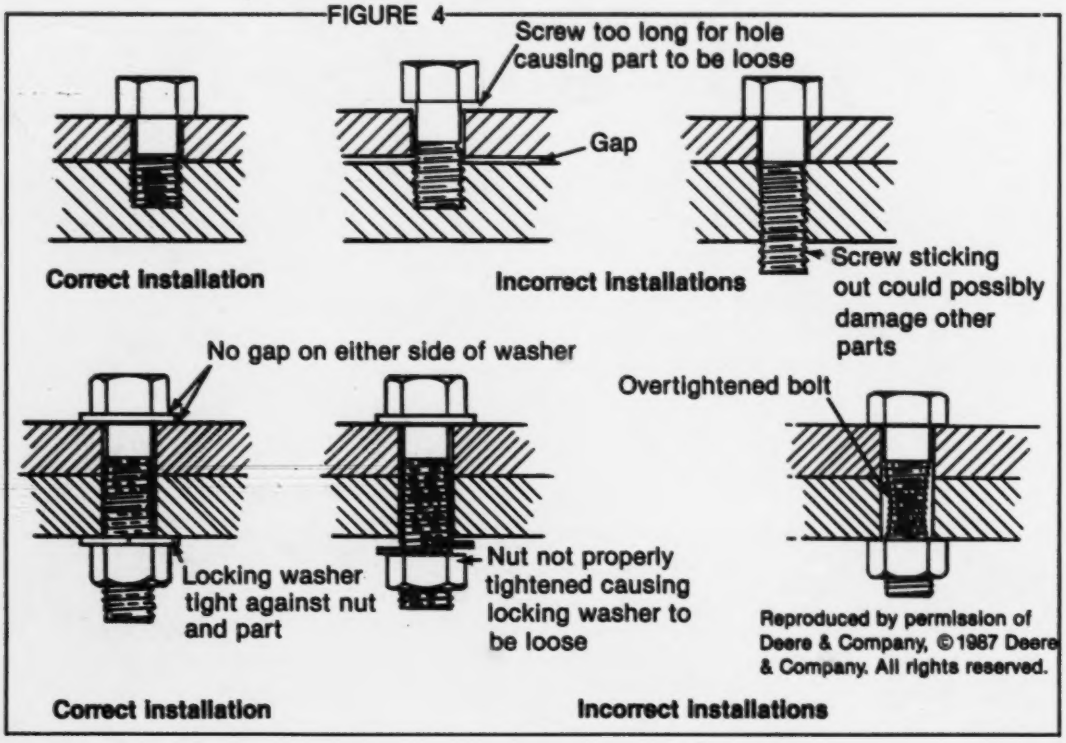
The decision about how long a fastener should be and how long the threaded portion should be is made by the engineers who design the vehicle. Normally, the service person will reinstall the original fastener or will use a similar fastener if the original fastener is unusable. However, the service person may occasionally have to replace a fastener that has been lost and be unable to determine the size of the lost fastener by checking other fasteners in similar installations. Also, the service specialist may occasionally have to drill out and replace a broken fastener, sometimes requiring the use of a fastener slightly larger than the original. When using or replacing a self-tapping screw, the service specialist should select one with a diameter slightly larger than the diameter of the hole in which it is to be inserted. This allows the self-tapping screw to cut into the material, tapping the hole as it is inserted.

In either of these cases, the specialist must determine what size of fastener to use. So how should a threaded fastener fit an installation? With nuts, the answer is fairly obvious—the nut must be the same diameter and have the same threading as the bolt or stud it goes on. Bolts and screws present more problems, but some general rules about installation are shown in Figure 4 below and in Figure 5 on the following page.

FIGURE 4


Screw too long for hole causing part to be loose
Gap
Correct installation
Incorrect installations
Screw sticking out could possibly damage other parts
No gap on either side of washer
Overtightened bolt
Locking washer tight against nut and part
Nut not properly tightened causing locking washer to be loose
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Correct installation
Incorrect installations

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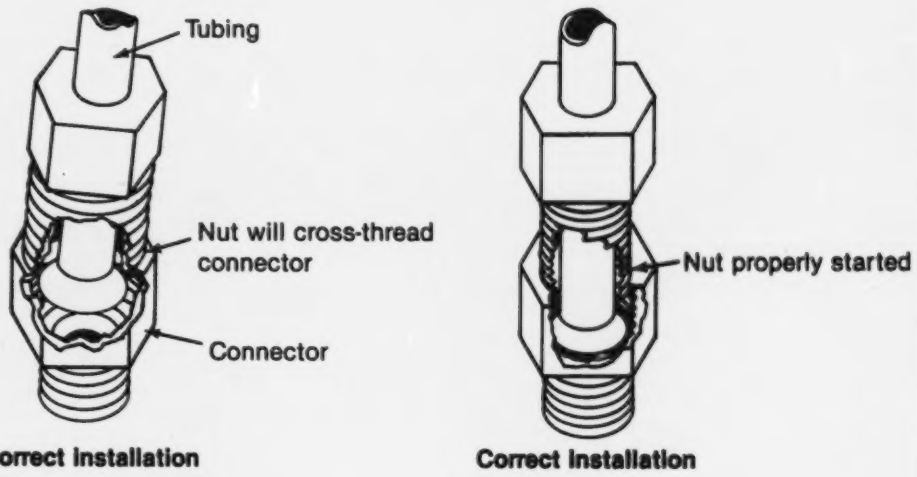
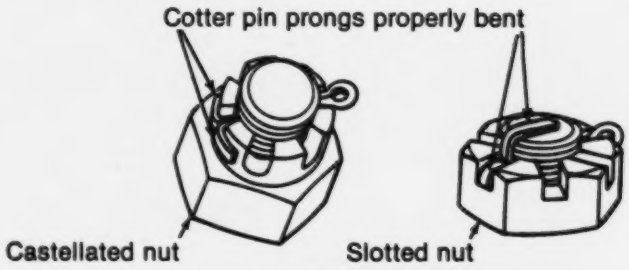
FIGURE 5



Incorrect installation **Correct installation**



Correct installations

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SUPPLEMENT 4

Tools Used to Remove and Install Threaded Fasteners

The purpose of any tool is to make a service person's work easier. As a result, tools are designed with specific jobs and parts in mind. This supplement looks at tools both in terms of the fastener with which the tool is designed to be used and in terms of the job to be performed. This is done in the following order:

- Tools used to remove and install bolts and nonslotted screws (wrenches)
- Tools used to remove and install slotted screws (screwdrivers)
- Tools used to remove broken or damaged threaded fasteners (extractors)

WRENCHES

General automotive service involves the use of three types of wrenches: external-fit, internal-fit, and specialty wrenches. As their names imply, external-fit wrenches are put over the outside of the fastener, while internal-fit wrenches go inside the head of the fastener. Specialty wrenches may be either external- or internal-fit wrenches but are designed for some purpose other than to simply remove or install fasteners. Let's look at each of these types of wrenches separately, beginning with the external-fit design.

External-fit wrenches

There are two major categories of external-fit wrenches. These are the *standard* wrench and the *socket* wrench. Table 1 on the next page describes some of the more common examples of standard external-fit wrenches and how they are used. Following the table is a more in-depth discussion of how standard wrenches are identified and used and a second table providing information about types of socket wrenches.

TABLE 1: Standard external-fit wrenches

Name	Description
Open-end	A wrench which is open on the end so that it can be slipped over a fastener. The wrench jaws fit against two opposite sides of the fastener. Open-end wrenches generally have one size of opening at one end with the next larger or smaller opening at the other end. **NOTE:** Wrench sizes are discussed in the section following this table.
Box-end	A wrench that is placed down over the fastener so that it completely surrounds the bolt head or nut. Box-end wrenches generally have six, eight, or twelve notches inside the wrench jaws. These notches fit the bolt head or nut so that the corners of the fastener match the wrench notches. Six- and twelve-notch wrenches fit hex nuts and hex-head bolts, while the eight-notch pattern fits square fasteners.
Combination	A combination wrench has a box-end opening and an open-end opening. Unlike box-end and open-end wrenches, which generally have different size openings at each end, most combination wrenches have the same size opening at each end.
Adjustable	An open-end wrench with one movable jaw so that it can be adjusted to fit over fasteners of various sizes. Adjustable wrenches are convenience tools not designed for heavy use. If a wrench of the correct size is available, use it.
Tubing	A box-end wrench with a slot cut out of it so that it can be slipped past tubing to go over a coupling. Tubing wrenches should be used for the removal and installation of any fastener used with tubing to help prevent twisting of the tubing.
Ratcheting	A box-end wrench designed to ratchet. The wrench applies pressure to the fastener when turned in one way, but turns freely when rotated the other direction. Used for close-quarter installations and removals such as may be required for some air conditioning service.

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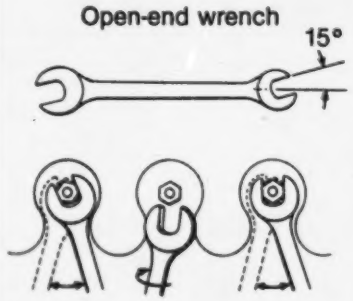
There are many variations in standard wrench designs, but the majority of automotive service work requiring wrenches is done with open-end, box-end, and combination designs. A closer look at these wrenches shows that they are manufactured with offsets to make them easier to use. The open-end wrench has a 12- to 15-degree offset between the center line of the handle and the center line between the jaws. In this way, the wrench can be flopped over to permit a wider range of motion when there is little room for turning the wrench, as shown in Figure 1.

FIGURE 1



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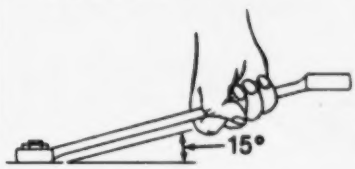
The head of the box-end wrench is generally aligned with the center line of the handle but turned from the handle. This improves ease of use by providing hand room and better leverage as shown in Figure 2.

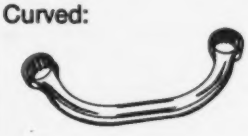
FIGURE 2



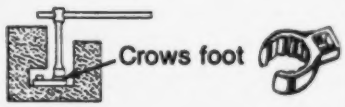
And There Are More!

Besides the common designs shown in Table 1, external-fit standard wrenches come in a variety of shapes and sizes for specific uses. Some of the more popular ones are shown below.

Curved:



Crows foot:



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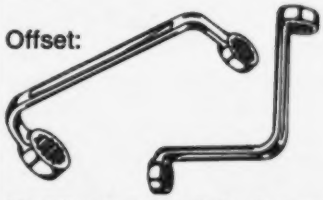
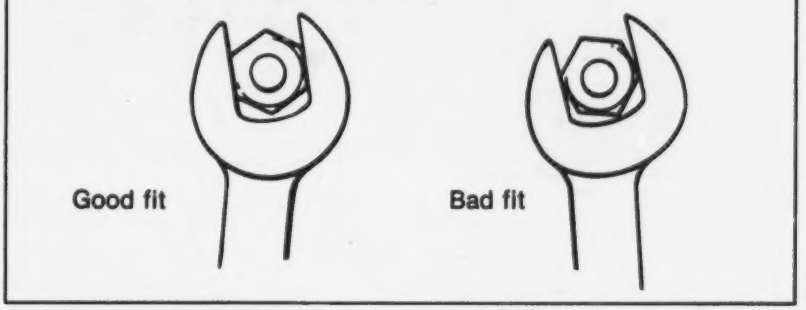
Offset:



Check your shop's tool room to see what other specialty wrenches are stored there.

There are two other important considerations in the use of standard wrenches once the proper design has been selected. The first of these is fit and the second is proper use. Each wrench is designed to fit a specific size of fastener. Normally, the size is stamped on the head of the wrench or on the handle nearer the end to which the size applies. The size may be a metric or U.S. customary dimension. Because metric and customary sizes are often very close to each other, you should check to make sure that the fit is exact. Otherwise, the wrench will slip, which could damage the fastener as well as your knuckles. Figure 3 compares a good fit with a poor fit.

FIGURE 3



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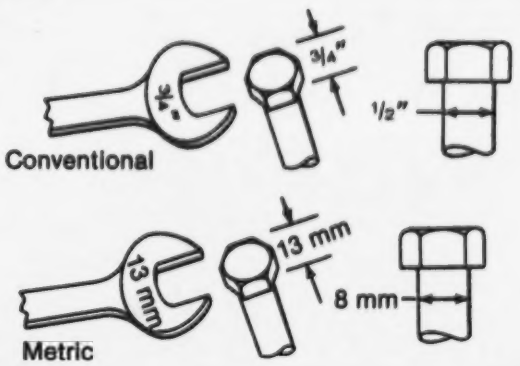
Sizes given on wrenches refer to the distance between two sides of the nut or fastener head, not the size (shaft diameter) of the fastener. Thus, a 3/4" wrench fits a 1/2" bolt and a 13 mm wrench fits an 8 mm bolt, as shown in Figure 4.

FIGURE 4



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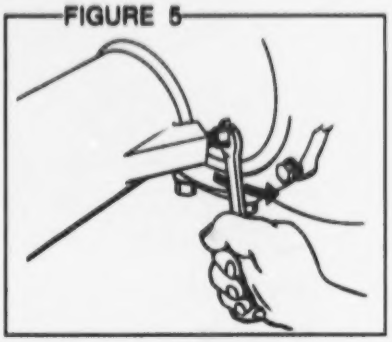
To use a standard wrench properly, place the correct size wrench as securely as possible over the fastener. Whenever possible, *pull* on the wrench instead of pushing on it as shown in Figure 5. If you have to push the wrench, keep your hand open and push with the heel of you hand. This will prevent you from hurting your hand if the fastener suddenly gives.

FIGURE 5



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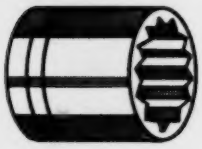
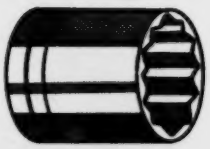
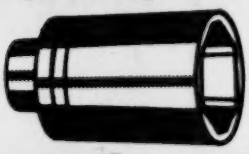
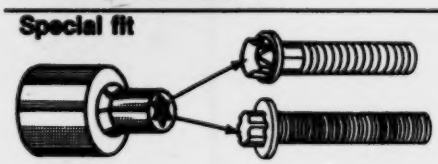
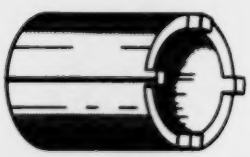
A socket wrench is similar to a box-end wrench. Inside the socket are notches designed to fit the corners on nuts and fastener heads. Sockets may have six-, eight-, or twelve-point designs, with six- and twelve-point being the ones most commonly used in automotive service. Although the base of the socket will probably be one of these patterns, the body of the socket may vary greatly for various uses, as shown in Table 2 on the next page.

TABLE 2: Types of socket bodies and their uses

Type	Use
Standard 	Used for normal removal and installation of nuts, bolts, and hex-head screws. EXAMPLES: 6-point 12-point
Thin-wall 	Used for installation and removal of fasteners in tight places where there is not enough room around the fastener for a standard socket. EXAMPLE: Thin-wall socket compared to standard socket Thin-wall socket Standard socket
Deep-well	Used to remove and install nuts on studs and on bolts that extend well beyond the fastened position of the nut.
Special body 	Used for threaded parts such as spark plugs, oil sensors, and temperature sensor. These sockets are designed with bodies to fit over specific parts.
Special fit  External torx socket and screws	Used for fasteners and threaded parts that are made with other than the standard six-, eight-, and twelve-point patterns. Such sockets may fit a different pattern. One example of a special-fit socket that is gaining use in vehicle manufacturing is the torx design shown at the left.
	Special-fit sockets may be specifically designed to work with particular fasteners. The illustration at left shows a socket used to remove the spindle nut on some four-wheel-drive vehicles.

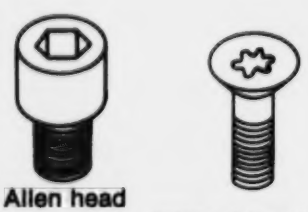
Sockets are sized just like standard external-fit wrenches and should be used with the same care. In fact, it is even more important to make sure that you have the correct size with sockets for it is not as easy to check the fit of a socket because you cannot see the fastener once the socket is in place.

The versatility of sockets is further increased through the use of special handles and accessories. Some of these are shown in the box at the right. Such handles and accessories generally make sockets faster to use or help them to reach fasteners that would be difficult to reach otherwise.

Internal-fit wrenches

The two most common types of internal-fit wrenches are designed for bolts and screws with either allen heads or torx heads. These head designs contain a hole in one of two specific shapes. The hole in an allen head is hexagonal (six-sided), while the torx head hole is similar to a six-pointed star, as shown in Figure 6.

FIGURE 6



Allen head

Internal torx head

Socket Handles and Accessories

Ratchet

Breakover

Speed

T

Nutdriver

Extension

Adaptor

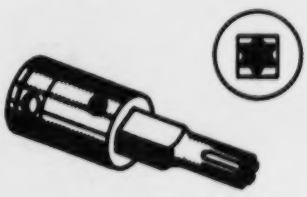
Flex (universal) joint

Allen wrenches are normally L-shaped bars with each end designed to fit a specific size allen head. The bar serves as its own handle, as shown in Figure 7.

FIGURE 7

Torx wrenches are normally made with socket fittings so that they can be used with nutdrivers or other types of socket handles and accessories. Figure 8 shows an example of an internal-fit torx wrench socket.

FIGURE 8



SCREWDRIVERS

Screwdrivers are those tools used to remove and install threaded fasteners with slotted heads. Actually, there is some overlap in types of tools used for threaded fasteners. As you have seen, some wrenches are made to fit into a hole in the head of the fastener, such as allen and torx wrenches. Screwdrivers also fit into holes or slots in the heads of screws. There is even a torx-head screw, so the terms do overlap some.

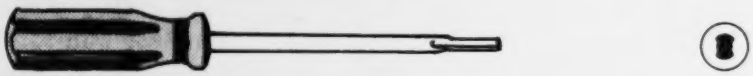
Screwdrivers are classified by their blades or points (the type of screw they fit) and their handles. Tables 3 and 4 on the next page show the most common types of screwdriver blades and handles used in the automotive service trade.

TABLE 3: Common screwdriver blades

Slotted

Phillips

Clutch



Torx

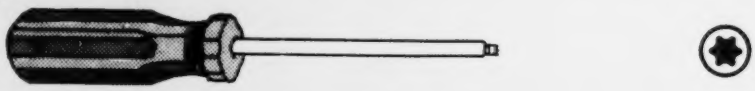


TABLE 4: Common screwdriver handles

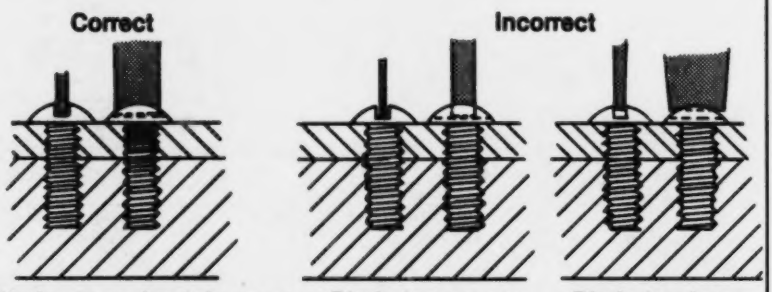
Standard

Ratcheting

Offset

Correct fit is just as important in the use of screwdrivers as in the use of wrenches. The blade of a screwdriver for slotted screws should fill the slot as much as possible, as shown in Figure 9. The blade should be approximately the same width as the screw head and as thick as the slot is wide.

FIGURE 9


Correct
Incorrect
Blade approximately same width as screw head and as thick as screw slot
Blade too narrow and too thin
Blade too large and too thick

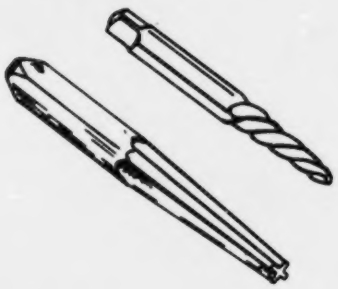
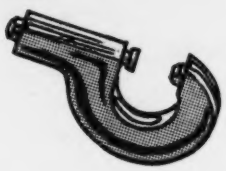
Blades on other types of screwdrivers should be the shape of the hole in the fastener head. The blade should bottom out in the hole and have little play between the blade and the sides of the hole.

EXTRACTORS

Extractors are tools designed to help remove fasteners that cannot be removed with the usual removal tool. For example, if an improper tool has been used to install a nut so that the corners have been rounded, a wrench may no longer be usable for removing the nut. Often threaded fasteners become stuck, because of rust, improper installation, overheating, or other reasons. Sometimes fasteners will break so that the normal removal process is no longer possible. Such situations call for the use of special tools called *extractors*. Extractors use a number of different techniques for removing fasteners, and their designs vary to match these techniques. Table 5 on the next page shows some of the more common extractors used in the automotive service trade. You will learn more about how to use them in the next unit when you learn to use power tools.

NOTE: Tools other than those discussed here may be used to remove damaged fasteners. These will be covered in more detail in the unit on hand and power tools. Table 5 on the next page lists those that are designed specifically for the removal of damaged fasteners.

TABLE 5: Common extractors and their uses

Name	Use
Impact driver	Used on screws that are difficult to remove because of damaged slots or holes. A bit in the end of the driver shaped like the fastener hole is driven into the hole with a hammer to provide enough "bite" to remove the fastener with the impact driver.
Extractor 	Used to remove fasteners that have broken off below the surface. A hole is drilled in the fastener. The extractor is then inserted in the drilled hole and turned with a wrench or handle. Some extractors are designed so that turning them counterclockwise cuts into the sides of the hole drilled in the fastener and twists the fastener from its hole. **NOTE:** Extractors are sometimes referred to as *easy-outs* after a brand name of one type of extractor.
Nutsplitter 	Used to break nuts that are stuck on bolts. The tool is tightened onto the nut and a blade on one side of the splitter cuts into the nut.

These, then, are the most common tools used to remove and install threaded fasteners used in automotive construction. Although they can be classed broadly as wrenches, screwdrivers, and extractors, there is some overlap among the functions of each and many design variations exist. You should become familiar with those in your shop and be alert for situations that call for the use of each.

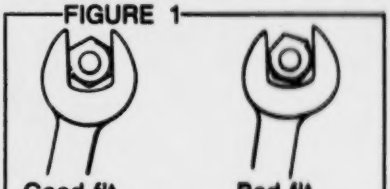
SUPPLEMENT 5

Guidelines for the Use of Threaded Fasteners

Use the right tool for the job. Use a tool that was designed to do the job you have to do. For example, do not use pliers to install or remove threaded fasteners. Use a wrench or socket.

Use the correct size tool. Tools come in different sizes to match various sizes of fasteners. A wrench that is slightly too large for a nut or bolt will ruin the corners on the fastener (Figure 1). Although metric and U.S. customary tools may seem to be the same size, the difference is enough to tear up fasteners.

FIGURE 1



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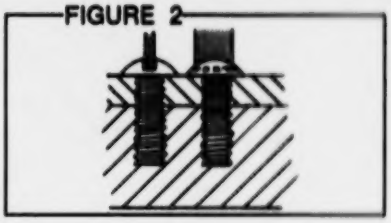
For a screwdriver to fit properly, the point of the screwdriver should seat fully in the slot or hole of the screw. For slotted screws, the tool should also fit the width of the slot and the diameter of the screw head.

FIGURE 2

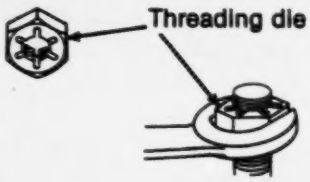


Torque

Torque is the measure of turning force. In automotive applications, torque is used to measure how much power is produced by an engine, turning shaft, wheel, or other rotating part. Torque is also used to measure how hard it is to turn a fastener. By measuring the torque required to turn the fastener, the specialist can tell how securely the fastener has been installed. One of the most important skills that you will learn as a automotive service specialist is how to install fasteners to the correct torque. It is a skill required in each specialty area. You may wonder why tightening fasteners to the correct torque is so important—why not just tighten all fasteners as hard as you can? For one thing, not everyone has the same strength. Also, the longer the tool handle, the more torque you can apply. In some installations, such as head bolts, the required torque may be more than most people can produce without the extra leverage of a long handle. But the most important reasons for measuring torque are to make sure that the fasteners are tight enough to hold the parts as required without over-tightening. Overtightening can stretch a fastener and weaken it or break it, meaning even more work to remove it.

Clean and inspect threads before installing fasteners; do not use fasteners with poor threads. Clean away dirt and oil with solvent and a cloth. Use a small wire brush or thread cleaner if there is cleanable rust or corrosion. Slight thread damage can be repaired with a threading die as shown in Figure 3. If in doubt about the fastener, replace it.

FIGURE 3



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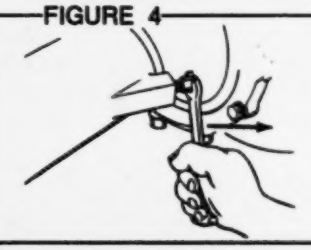
Hand-start fasteners. Use light finger pressure to get a fastener started so that you can be sure the threads are properly mated before using a tool to install fasteners.

Hold tools properly. Hold tools firmly to keep them from slipping. Position your hand and move the tool so that if the tool does slip, you will avoid injuring you hand, as shown in Figure 4 below. Generally, this means that you will want to pull on the tool rather than push it.

FIGURE 4



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Antiseize Compound and Lubricants

Antiseize compound is a substance that can be applied to fasteners to make them easier to remove. It is used primarily when a steel fastener is used in aluminum, such as a bolt that goes into a hole in an aluminum engine block. The compound protects the bolt from rust and corrosion that might cause the bolt to seize in the hole. Some specialists use antiseize compound in any installation where rust or corrosion is a danger, such as on exhaust parts.

For some installations, a manufacturer may recommend that the fastener be given a light coat of oil prior to installing it. The oil makes the fastener easier to install by reducing *friction*, the force between two objects touching each other. But you have to be careful with this practice, especially where torque readings are important. Up to 90 percent of the torque required to tighten a bolt is used to overcome friction, which means that the use of a lubricant can give an incorrect torque reading. Some manufacturers provide separate torque readings for when oil is used, so make sure you know how the torque is measured. Also, oil can get under a bolt, and since the oil will not compress, the bolt may act like it has reached the bottom of the hole.

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When possible, hold the bolt and turn the nut when working with nut-and-bolt assemblies.

Do not reuse fasteners that must be distorted during the removal or installation process except as recommended by the vehicle manufacturer. Generally, nuts and bolts that have thread distortions, plastic inserts, or installations that stretch them to near their limits of stretch should not be reused. In some cases, the vehicle manufacturer will specify conditions for reusing such fasteners. If in doubt, do not reuse such fasteners. Be especially careful when working with fasteners referred to as *prevailing torque* or *torque-to-yield* fasteners because such fasteners are designed for use very near the limits of their holding power in the first installation.

Follow manufacturer's instructions for installing and removing fasteners. The vehicle manufacturer may specify the sequence in which a series of fasteners should be installed. They may also specify how much torque should be used. *Torque* is a measure of turning force and is used to determine how securely a threaded fastener has been installed, using a special tool called a *torque wrench*. For most fasteners, manufacturers will specify how much torque should be used for the installation. The manufacturer may also specify other installation or fastener inspection guidelines, such as grade of fastener, fastener material, and whether to use lubricants or antiseize compounds with the installation.

The Story of Mary Ann Taylor

Mary Ann Taylor had worked on cars for most of her life. Her father had been a mechanic, and Mary Ann spent a lot of time in his shop while she was growing up. She learned a lot from her father, but maybe not quite enough. In high school, Mary Ann took an auto mechanics course. At the time, she was the only girl in her class, and even though she knew as much about cars as anyone in her class, she still felt that she had to prove herself. She wasn't happy knowing that no one could do a better job at overhauling a carburetor. She wanted the guys in her class to know that she could do anything that they could. So she never asked for help, even when she needed it. One day, Mary Ann was removing the spark plugs from an engine when she found one that would not turn. She tried and tried, but the spark plug would not budge. Finally, she got the biggest socket handle she could find, climbed up in the engine compartment, and yanked as hard as she could. The spark plug twisted in two, and Mary Ann fell, breaking her leg. What she didn't know is that the spark plug had *seized* in the engine block. No amount of force would have gotten it out. It had to be drilled out and the threads retapped. Mary Ann knows. . . now.

REMOVE AND INSTALL COMMON FASTENERS

SUPPLEMENT 6

Nonthreaded Fasteners

Many of the fasteners used in automotive construction are not threaded. Clamps, pins, rings, rivets, and even adhesives are used to hold vehicles together. These devices may be common designs or specially manufactured for specific applications. As with threaded fasteners, they must be properly installed if the vehicle is to function correctly. This supplement describes those nonthreaded fasteners most commonly used in automotive construction and gives examples of how they are used. Generally, these fasteners fall into eight categories, which are summarized in Table 1 below and on the next two pages.

TABLE 1: Nonthreaded fasteners and their uses.

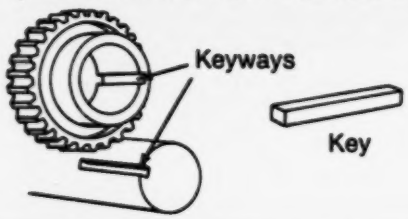
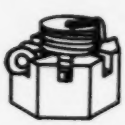
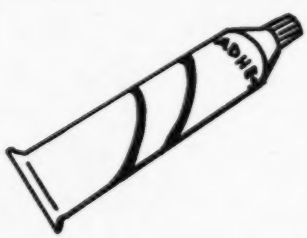
Name	Use
Keys • Woodruff • Square 	Keys are fitted into a slot on a shaft to hold in place another part that goes over the shaft. Keys are commonly used to hold pulleys, collars, and other parts on shafts in automotive construction.  Reproduced by permission of Deere and Company, ©1987 Deere & Company. All rights reserved.
Pins • Cotter 	Pins are inserted through holes to hold parts together or in place. *Cotter pins* are inserted through holes and bent so that they will not slip out of the hole. Frequently, they are used with slotted nuts to keep the nut from coming off, as on a wheel spindle. They are also used to keep linkages from coming off rods, as on throttle linkages.
• Roll (split) 	*Roll pins* are most often used to hold collars or other parts in place on rotating shafts. They are often used to hold spacers, gears, and the pickup coil assembly on the distributor shaft.

TABLE 1 (Continued)

Name	Use
• Spring	*Spring pins* are designed to hold linkages on rods. The straight arm of the pin goes through a hole in the rod, while the curved arm of the pin fits over the outside of the rod. Spring pins are used for light linkages, such as those found on carburetor actuating rods.
Clamps • Wire • Worm-drive • Banded	Clamps are used to hold soft, rubber parts to hard, round connections. Several examples are shown at left. *Wire*, *worm-drive*, and *banded clamps* are most often used to hold cooling system hoses in place.
• Crimp	*Crimp clamps* are used on smaller hoses, such as fuel line connections.
• Strap	*Strap clamps* are used primarily on the rubber boots found in the steering linkages and drive shafts of many front-wheel-drive vehicles. Strap clamps use a variety of buckle designs and may require special tools for installation.
Snap rings • Internal Hole type Prong type • External Hole type E type	Snap rings fit into grooves on the inside or outside of a shaft. With the snap ring in place, another part is prevented from moving along the shaft. Snap rings may be metal strips or shaped wires. They are frequently used with wheel bearings, on air-conditioner compressor shafts, and in transmissions.

TABLE 1 (continued)

Name	Use
Springs 	Springs are used to hold parts in place by creating tension. Springs vary greatly in size, from small springs used to hold carburetor needle valves in place to the large springs used in suspension systems.
Rivets 	Rivets are fasteners that are not reusable. A rivet is inserted through a hole and deformed so as to stay in place. Rivets are used on automotive body panels, on assembly housings, and other parts that are not designed to be disassembled.
Clips • Snap clip • Retaining clip 	The term *clip* applies to a wide variety of devices that hold parts in place. Many clips are designed for easy opening, such as those on the air filter housing. Others, such as the fan retaining clip, are harder to remove.
Adhesives 	Adhesives are various substances such as glues and sealants that are designed to bond parts together. The use of adhesives is becoming more and more common in automotive construction because of their light weight, resistance to corrosion, relative ease of installation, and other properties. Adhesives are frequently used to attach rearview mirrors, attach housings, install stationary glass, join electronic parts, may be used to attach body side moldings on some automobiles, and provide other connections.

Crimping

One method of fastening that is used in a number of ways in automotive construction is *crimping*. Crimping simply means deforming or bending a material. One example of crimping already mentioned is crimp clamps. Crimping is also used in the assembly of components not intended to be serviced. For example, most thermostat housings are crimped together. Some automotive radiators are assembled by crimping tabs on the core over a flange on the tank, especially with plastic tanks.

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These nonthreaded fasteners play an important role in the construction of vehicles, and the service specialist must be familiar with how they work. Frequently, you will encounter parts and components whose construction is not apparent. By understanding the variety of fasteners used in automotive construction, you are more likely to be able to figure out how parts are held together as you service vehicles.

Now, study a vehicle or a service manual. How many uses for nonthreaded fasteners can you find?

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SUPPLEMENT 7

Tools Used to Remove and Install Nonthreaded Fasteners

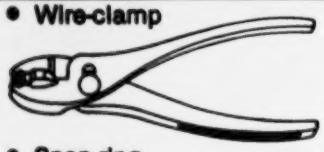
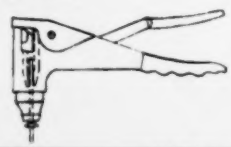
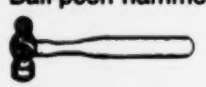
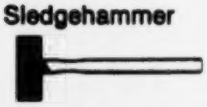
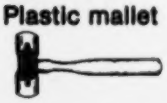
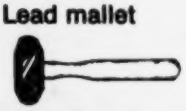
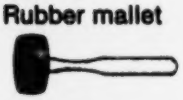
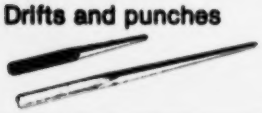
Most nonthreaded fasteners are installed and removed by either pushing them or pulling them. As a result, the tools used with these fasteners are designed for gripping the fastener or driving it. Many are either hammers or pliers, but most are designed to do specific jobs efficiently.

Table 1 below shows some of the tools commonly used in automotive service for installing and removing nonthreaded fasteners.

TABLE 1: Tools used with nonthreaded fasteners.

Name	Use
Pliers • Slip-joint 	Pliers are used to grip fasteners or parts during the installation and removal process. They are also used to bend parts that must be deformed, such as cotter pins. The most commonly used pliers is the *slip-joint* design, which can be used to hold pins for insertion or removal, to grip springs, to compress clips and expand wire clamps, etc.
• Arc-joint 	*Arc-joint* pliers are designed to grip large objects firmly without damaging them. They are frequently used to hold shafts and other parts so that nonthreaded fasteners can be inserted or removed.
• Diagonal cutting 	*Diagonal cutting* pliers are designed to cut wire, but they are also useful for installing cotter pins and for crimping crimp clamps.
• Needle-nose 	*Needle-nose* pliers are used to hold small fasteners and to reach those in small areas or in narrow holes.
• Locking 	*Locking pliers* can be clamped shut in a desired position. They are useful in holding shafts and other parts when working with nonthreaded fasteners or for removing damaged fasteners, such as cotter pins and even rounded nuts and bolts.

TABLE 1 (continued)

Name	Use
• Wire-clamp 	*Wire-clamp* pliers are used to install and remove wire clamps used to attach hoses. These pliers are sometimes called hose-clamp pliers.
• Snap-ring	As their name implies, *snap-ring* pliers are used to install and remove snap rings. The pliers may be for either internal or external rings or may have removable bits that allow them to be converted from one type to the other. **NOTE:** Many other specialty pliers exist, as shown in the boxed item on the next page.
Rivet Gun 	Rivet guns are used to install rivets in drilled holes.
Hammers and Mallets • Ball-peen hammer  • Sledgehammer  • Plastic mallet  • Lead mallet  • Rubber mallet  • Drifts and punches 	Hammers and mallets are used in two ways for installing and removing nonthreaded fasteners. They may be used to pound directly on the fastener or part, or they may be used with a drift or punch. Hammers and mallets may be used to drive pins, finish rivets, deform fasteners, position parts, and other functions associated with the installation and removal of parts. Depending on the size of the fastener and whether there is a danger of damaging the fastened parts, a hard hammer, such as a *ball-peen hammer* or *sledgehammer*, may be used or a soft-faced mallet may be required. The size and location of the fastener may also determine whether a *drift* or *punch* is required, such as for driving roll pins from holes in shafts.

There are many specialty tools used to remove and install specific nonthreaded fasteners. You will learn about these as they are required during your training.

As you continue your studies, pay attention to fasteners that you encounter. Note how they are used and what tools are needed to remove and install them. You will find as you continue your career in automotive service, that each model year will introduce new fasteners. But by understanding the basic fasteners discussed in this unit, you will be able to work with most fasteners that you encounter.

Special Pliers

The automotive service trade makes use of a number of special pliers and other tools similar in design. Crimping pliers are shown in the previous supplement. Even the types covered in this supplement come in many different sizes and variations of design. Study the special pliers illustrated below, and then check your shop's tool room to see what others you can find.

Curved long-nose pliers

Battery pliers

Brake-spring pliers

ASSIGNMENT SHEET 1	REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 3

Identify threaded fasteners by their characteristics

Name _____ Score _____

INTRODUCTION

Threaded fasteners are used throughout vehicles and are involved in almost every service procedure. These fasteners come in a variety of designs with various purposes, limitations, and requirements for use. This variety is necessary because of the many different functions of automotive systems and the varied conditions under which those functions are performed. The skilled service specialist is able to select the proper fastener to use in specific situations. To do so, the specialist must be able to determine what fastener characteristics are required for a particular application and then identify a suitable fastener that offers the required characteristics. This assignment sheet and the student supplements that go with it will help you learn how to identify fasteners by their characteristics.

DIRECTIONS

This assignment sheet is divided into several parts, each dealing with a different characteristic of threaded fasteners. Read each part and the supplements that go with it, and then answer the questions in each part.

PART A DESIGN

Read Student Supplement 1, "Threaded Fasteners." Use the supplement to answer the questions in Part A.

1. What threaded fastener should be used to position a drive gear on a distributor shaft?

   _____

2. What type of nut should be used on a threaded shaft so that a cotter pin can be installed to hold the nut in place?

   _____

3. A fastener that is threaded on both ends, frequently used to align gaskets between joined parts, is called a

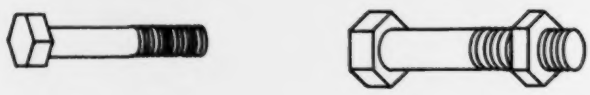
   _____

4. Automotive parts are sometimes attached to body panels with fasteners that are installed into nonthreaded holes in the body panels. What are such fasteners called?

_____

5. In the drawings below, which illustration represents a bolt and which represents a cap screw?

Illustration A **Illustration B**



Cap screw: Illustration _____

Hex bolt: Illustration _____

6. The type of nut normally used for installations that allow removal of the nut without tools is a

_____

7. What type of threaded fastener is likely to be used to install a strip of molding to an interior plastic surface?

_____

8. When installing a washer with a nut and bolt, does the washer normally go between the nut and the part or between the bolt head and the part?

_____

9. Tubes are normally joined to each other or to other parts by using what type of threaded fasteners?

_____

10. What kind of washer is used to make a more secure hold by exerting pressure against the nut or bolt head?

_____

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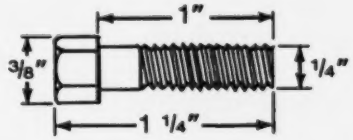
PART B
SIZES

Read Student Supplement 2, "Characteristics of Threaded Fasteners," and Student Supplement 3, "Threaded Fastener Sizes." Then answer the following questions.

1. What is the correct diameter and length of the cap screw illustrated below?

   Diameter = _____ inch

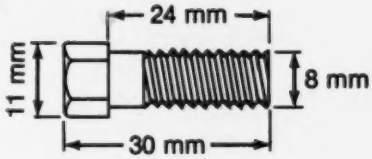
   Length = _____ inch



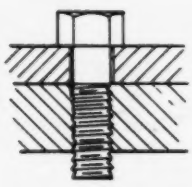
2. What size bolt is illustrated below?

   Diameter = _____ millimeters

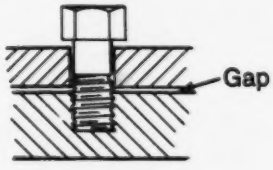
   Length = _____ millimeters



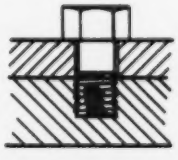
3. Place an "X" beside the illustration below that shows a properly installed fastener.



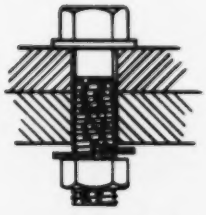
_____ Illustration A



_____ Illustration B



_____ Illustration C



_____ Illustration D

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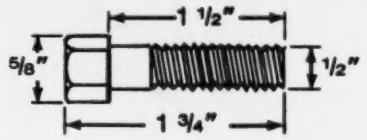
4. Using the information in Student Supplement 2, determine the dimensions of the fasteners shown below. Write the dimensions in the spaces provided.

Fastener A

Length = _____

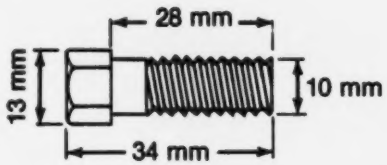
Diameter = _____



Fastener B

Length = _____

Diameter = _____



PART C MARKINGS

Threaded fasteners are often marked to show some of their characteristics. Bolts, cap screws, and nuts may be marked to show their tensile strength. Review the information about fastener markings in Student Supplement 2, then answer the following questions.

1. Which of the following fasteners are metric fasteners? Write an "X" in the blank beside each metric fastener.

_____ Fastener A

_____ Fastener B

_____ Fastener C

_____ Fastener D

2. Study the fasteners below and decide which has the highest tensile strength. Number the fasteners in each group to show their relative strengths. Write a "1" beside the fastener with the highest tensile strength in each group, a "2" beside the one with the next highest tensile strength, and so on.

Group A

____ a.

____ b.

____ c.

Group B

____ a.

____ b.

____ c.

3. Identify the direction of threading of the fasteners illustrated below. Write a "C" in the blanks beside those that have clockwise threading and a "U" beside those that have counterclockwise threading.

____ a.

____ b.

____ c.

____ d.

PART D PITCH

Pitch is the measurement of the space between similar points on adjoining threads. Pitch is measured in number of threads per inch or distance between threads in millimeters. But fasteners are normally referred to with terms such as *coarse*, *fine*, and *extra fine*.

1. Classify the threads in the illustrations below as *coarse*, *fine*, or *extra fine*.

a. _____ b. _____ c. _____

2. What is one of the normal characteristics of the threads on studs that makes studs different from most threaded fasteners?

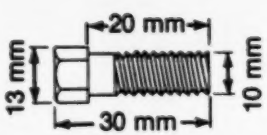
_____

_____

PART E DESCRIPTIONS

A description of a threaded fastener should include as a minimum the type of fastener, any special design features, its material, its measurement system, its size, and its pitch. Depending on the type of fastener and its application, other information may also be necessary to provide an adequate description, such as the length of a bolt or the grade of the fastener. Using the information and charts in Student Supplement 2 and 3, interpret the information given about the screws illustrated below and on the following pages.

1. Study the fastener illustrated and the description given. Provide the information requested.



M-10 × 2.00 × 30 – 5.8

a. Measurement system _____

b. Length _____

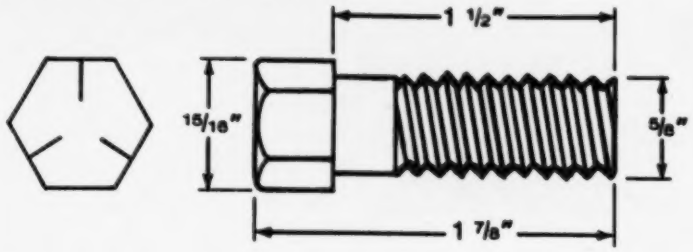
c. Pitch _____

d. Diameter _____

e. Grade _____

910

2. Study the fastener illustrated and the information given. Provide the information requested.



a. Measurement system _____

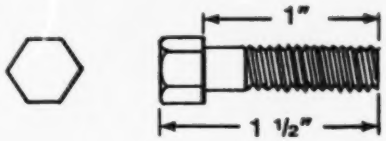
b. Diameter _____

c. Length _____

d. Threads per inch
(fastener has fine threads) _____

e. Grade _____

3. Study the fastener illustrated and the description given. Provide the information requested.



10 – 24 UNC – 2A × 1

a. Measurement system _____

b. Diameter _____

c. Length _____

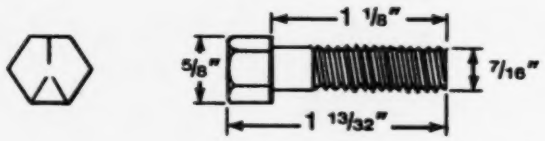
d. Threads per inch _____

e. Fit _____

f. Grade _____

911

4. Study the fastener illustrated. Provide the information requested.



a. Measurement system _____

b. Diameter _____

c. Length _____

d. Threads per inch
(fasteners has coarse threads) _____

e. Grade _____

912

ASSIGNMENT SHEET 2

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 4

Select correct threaded fasteners for specific applications

Name _____ Score _____

INTRODUCTION

The most important reason for studying fasteners is so that you will be able to use the correct fasteners while working on vehicles. Any or all of the characteristics used to identify fasteners may be important in selecting the correct fastener for a specific application.

In most cases, the service specialist will simply use a fastener identical to the one that was removed. But when a fastener has been lost or if a broken fastener must be replaced, the specialist must be able to determine the required fastener.

There are several sources of information to assist the specialist in determining the required replacement fastener. If the original fastener is still available, it can be used to select the replacement fastener. If the fastener being replaced is one of several in a similar installation, other fasteners in the installation may give clues to the characteristics of the fastener being replaced, though often there are some differences in such fasteners. Sometimes information about the required fastener can be found in the service manual.

This assignment sheet will help you develop skills in selecting fasteners for specific applications.

DIRECTIONS

Read the situations described below and on the following pages. Using Student Supplements 1-3, the information you have studied, and service manuals, answer the following questions. Write the correct answers in the spaces provided or write an "X" in the blanks beside the correct answers.

1. You are working on a 1983 Chevrolet Monte Carlo. A cap screw that you have removed has a plastic insert patch along one portion of the threads. Under what conditions can this fastener be reused?

   _____

   _____

   _____

2. The fastener at the right must be replaced due to damaged threads. Which of the following fasteners would be a suitable substitute?

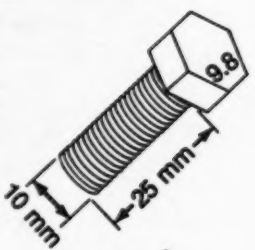
____ Fastener A

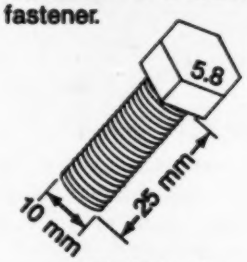
____ Fastener B

____ Fastener C

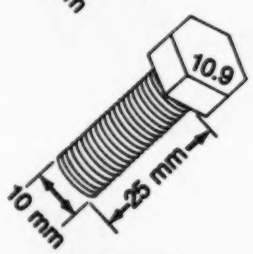
____ Fastener D

3. The fastener at the right has damaged threads that cannot be repaired. If you had to choose from among the fasteners shown below, which would be a suitable replacement? Write an "X" by each illustration of a usable replacement fastener.

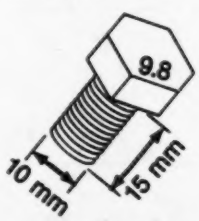




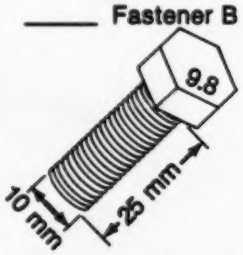
____ Fastener A



____ Fastener B

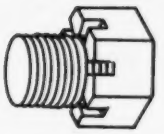


____ Fastener C



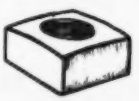
____ Fastener D

4. Study the fastener installation at the right. Which of the fasteners illustrated below would be used to complete the installation so that the nut will not come off the spindle? Write an "X" beside each fastener that could be used.



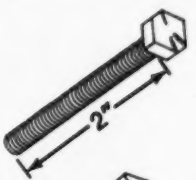
_____ Fastener A _____ Fastener B _____ Fastener C

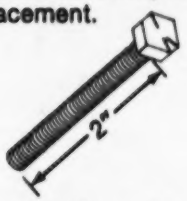
5. You must replace a nut that has damaged threads that cannot be repaired. The nut is a locking nut. Which of the following are locking nuts? Write an "X" beside each.



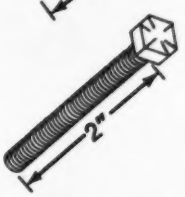
_____ Fastener A _____ Fastener B _____ Fastener C

6. You must replace the fastener illustrated at the right. Which of the fasteners shown below is a suitable replacement? Write an "X" beside each acceptable replacement.



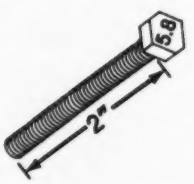


_____ Fastener A



_____ Fastener B

_____ Fastener C



_____ Fastener D

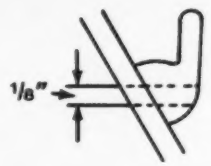
915

7. What diameter of head bolts are used for the following models of Chrysler Corporation 2.2-liter engines?

   a. 1984—_____ mm

   b. 1986—_____ mm

8. A clothes hook has come off and the fastener has been lost. The illustration below shows the installation. Which of the fasteners listed should be used to reinstall the clothes hook? Write an "X" beside the correct answer.



   _____a. 4 × 1/2", machine screw

   _____b. 8 × 1/2", machine screw

   _____c. 4 × 1/2", self-tapping screw

   _____d. 8 × 1/2", self-tapping screw

9. A stud, installed in a 1981 Ford Thunderbird, has broken off. You have removed the broken stud and are ready to replace it. The end of the stud is marked as shown at the right. Which of the studs illustrated below could be used as a replacement if the dimensions are correct? Write an "X" beside each stud that could be used.

_____ Stud A _____ Stud B _____ Stud C

10. You must mount a section of molding to the plastic surface of an interior door panel. What type of screws should be used?

_____

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ASSIGNMENT SHEET 3

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 5

Select correct tools to use in removing and installing threaded fasteners

Name _____ Score _____

INTRODUCTION

Just as it is important to use the correct fastener for a particular installation, it is also critically important to use the proper tools to remove and install fasteners. A proper tool is one that is designed to do the job and that is the correct size. Failure to use the proper tool can lead to damaged fasteners and tools, eat away your valuable time, mean that the fastener is not properly installed, and even result in injuries.

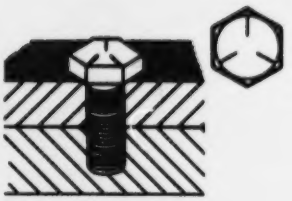
The tools you will use to remove and install threaded fasteners are those that are commonly found in personal tool boxes and special tools available from vehicle manufacturers and tool suppliers.

This assignment sheet will give you practice in selecting the correct tools to use in removing and installing threaded fasteners.

DIRECTIONS

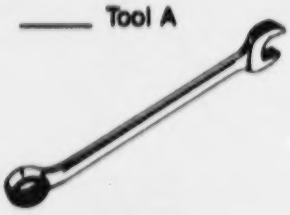
Read Student Supplement 4, "Tools Used to Remove and Install Threaded Fasteners," and then read the situations described below and on the following pages. Each situation describes the installation or removal of a threaded fastener and then offers a choice of tools for performing the required procedure. You will need to refer to the appropriate service manual or professional manual for some of the situations. Write an "X" in the blank beside the tool in each group that would work *best* in doing the required job, or write the correct answers in the blanks provided.

1. The illustration at the right shows a cap screw installation and a detailed drawing of the cap screw head. Which of the tools illustrated below should be used on this cap screw?



_____ Tool A

_____ Tool B



_____ Tool C

_____ Tool D

2. You must remove the screw shown in the illustration at the right. Which of the tools below could be used to remove this fastener? Mark all that could be used.

_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

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3. Using the correct size of tool, you cannot loosen a nut, and you determine that the nut has rusted in place. Which of the following tools is best suited for removing the nut?

_____ Tool A

_____ Tool B

_____ Tool C

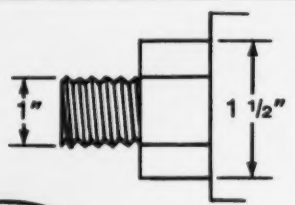
_____ Tool D

4. The tool shown at the right is used to remove damaged threaded fasteners. What sort of damaged fasteners can be removed with this tool?

_____

_____

5. A one-inch-diameter nut must be installed on a wheel spindle as shown in the illustration at the right. Which of the illustrated tools should be used for this installation?



_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

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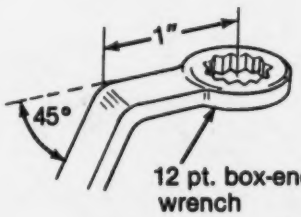
6. You are working on a 1985 Cadillac. It is a full-size model with Electronic Level Control and rear-wheel drive, and you are removing the shock absorber. A special tool must be used to remove the upper retaining bolts. Which of the tools shown below is the right tool to use for this procedure, including the required modification to the tool?

_____ Tool A

_____ Tool B



_____ Tool C

_____ Tool D

7. Which of the tools shown below is required to adjust the tension on a Chrysler 2.2-liter engine drive belt?

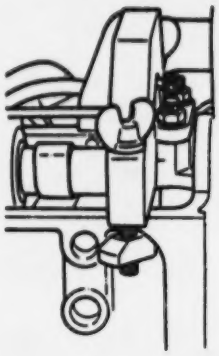
_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

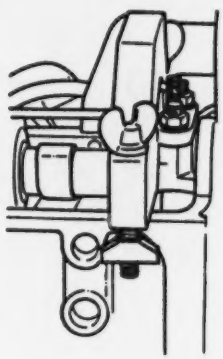
8. **A special tool is required to position the camshaft on the 2.4-liter diesel engine used in early-1980s-model Ford vehicles. Which illustration below shows the tool with the adjusting nut properly installed?**



_____ Tool A

_____ Tool B

_____ Tool C



_____ Tool D

Figure for question 6-c courtesy Cadillac Motor Car Division, General Motors Corporation.

Figures for question 7 used with permission of Chrysler Corporation.

Figures for question 8 used/adapted from *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

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ASSIGNMENT SHEET 4	REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 6

Apply guidelines for the use of threaded fasteners

Name _____ Score _____

INTRODUCTION

Threaded fasteners used in the construction of motor vehicles are designed to hold those vehicles together. To do so, the fasteners must be properly installed. Proper installation involves more than simply putting the fasteners in place and tightening them. Fasteners break down with use and must be inspected before reuse. The installation must follow the manufacturer's instructions, including torque specifications. By following the general guidelines for the use of threaded fasteners and the vehicle manufacturer's specific instructions, a good service specialist can ensure that completed installations will hold together as designed. This assignment sheet will help you apply the guidelines required for the proper use of threaded fasteners.

PART A DIRECTIONS

Read Student Supplement 5, "Guidelines for the Use of Threaded Fasteners," and then complete the following statements by writing the correct words in the blanks.

1. Using the correct size of tool is important. For instance, a wrench that is slightly too large will ruin the _____ of the fastener.

2. For a screwdriver to fit properly, the point of the screwdriver should _____ _____ in the slot or hole of the screw.

3. You should always _____ and _____ the threads of a fastener before installing it.

4. To be sure that the threads are properly mated, you should _____ a fastener before using a tool to install it.

5. It is important to hold tools properly. When working with wrenches, you should _____ the tool rather than _____ it.

PART B
DIRECTIONS

Read the situations described below. Using the guidelines given in Student Supplement 5 and information given in service manuals or professional manuals, answer the questions with each situation.

1. You have to adjust the wheel bearings on a 1986 Mercury Merkur XR4Ti. What three steps are required to properly tighten the spindle nut?

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

2. While servicing a 1988 Chevrolet Eurosport, you must reinstall a 12 mm prevailing torque nut with a nylon insert. You have cleaned the nut and found no defects upon inspecting it. On the final turn before the nut seats, the torque wrench registers 14 inch-pounds. Can the fastener be used? Why or why not?

   _____

   _____

3. You are servicing the strut damper assembly on the front suspension of a 1985 Chrysler LeBaron GTS. Two bolts, washer plates, and nuts are used to secure the strut damper assembly to the steering knuckle. Can the bolts be reused during reassembly? Why or why not?

   _____

   _____

   _____

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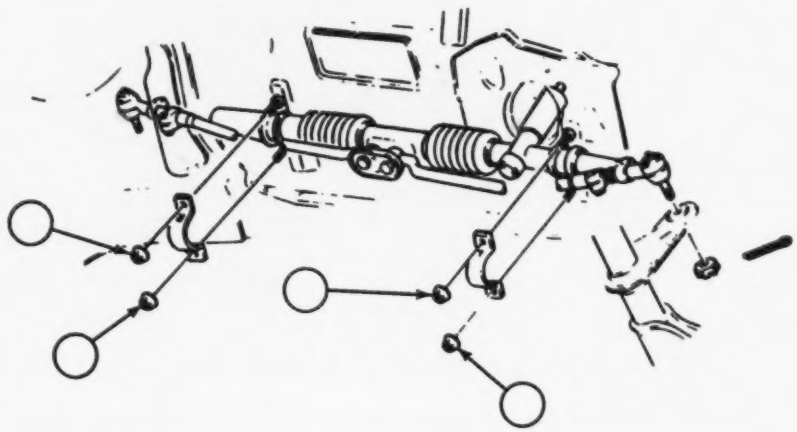
4. You are reinstalling the rack and pinion steering unit on a 1985 Buick Skyhawk. Four studs and nuts are used to hold the clamps that secure the steering unit. In the illustration below, number the securing nuts in the correct installation sequence. Number the first nut to be installed with a "1," the second with a "2," and so on.



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

5. You are replacing the cylinder head on a 1985 Ford equipped with the 2.0-liter diesel engine. You measure the head bolts as recommended by the manufacturer and find that four bolts are just under four-and-one-half inches long, two are four-and-one-half inches long, and four are nearly four-and-nine-sixteenths inches long. Which, if any, of the bolts must be discarded?

_____

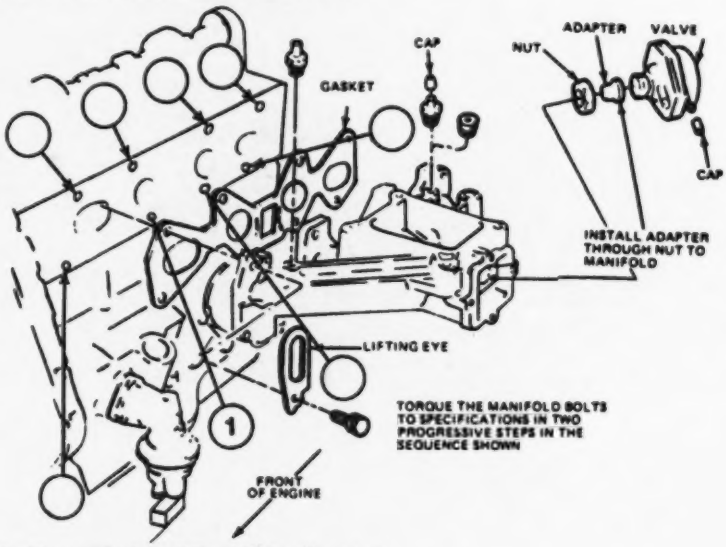
_____

_____

6. Label the correct torque sequence in the illustrations below and on the next page for the type and model of vehicle listed. Write the correct numbers in the circles.

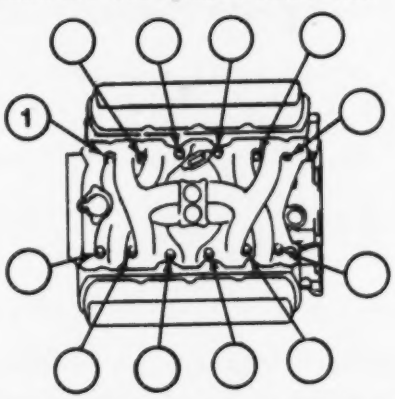
NOTE: The first fastener is labeled for you.

a. Ford 2.3L intake manifold



Used with permission of Ford Motor Company.

b. GMC 307 CID cylinder head bolts



Used with permission of General Motors Corporation, Oldsmobile Division.

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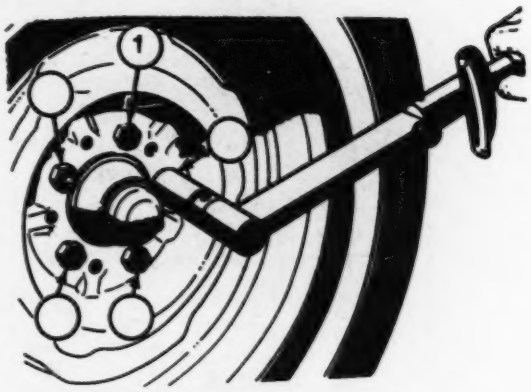
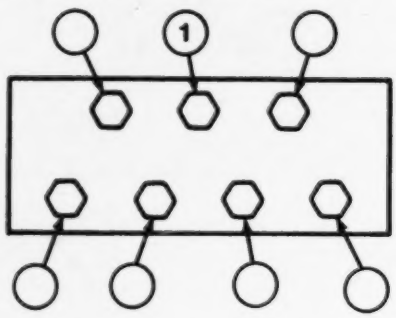
c. Chrysler five-bolt wheel lugs



Used with permission of Chrysler Corporation.

d. AMC 151 CID exhaust manifold



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

7. Use shop manuals to determine the torque values for the following vehicles and installations.

	Vehicle	Fastener	Torque
a.	AMC Eagle, 150 CID	Oxygen sensor	_____
b.	Chrysler, 2.2L	Intake manifold	_____
c.	Ford, 2.3L	Oil pan, 8 mm screws	_____
d.	Ford, 2.3L	Oil pan, 6 mm screws	_____

8. Some threaded fastener installations require the use of sealants, oil, or other treatments during installation. Determine the treatments required for the following installations. Write "None" if no treatment is required.

Installation	Treatment
a. GMC 263 CID intake manifold	_____
b. Ford 2.0L diesel cylinder head bolts	_____
c. AMC 151 CID water pump mounting bolts	_____

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ASSIGNMENT SHEET 5

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 7

Select correct nonthreaded fasteners for specific applications

Name _____ Score _____

INTRODUCTION

For many reasons, some construction designs call for the use of nonthreaded rather than threaded fasteners. Nonthreaded fasteners come in a variety of types and sizes which affect their suitability for different applications. The service specialist must be aware of the various types available and understand how they are used so that proper service can be provided. This assignment sheet will help you see how nonthreaded fasteners are used in automotive design and construction.

DIRECTIONS

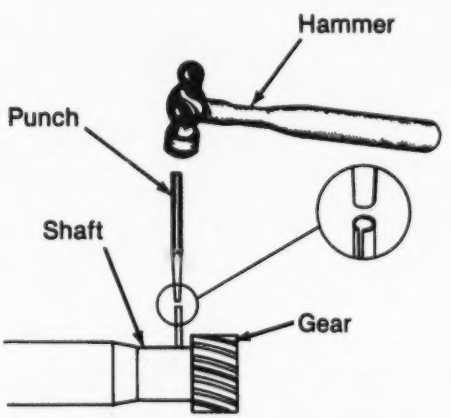
Read Student Supplement 6, "Nonthreaded Fasteners." Then read the following situations and answer the questions with each.

1. On many vehicles, a nonthreaded fastener is used to hold the wheel spindle nut in place. This is done because the turning of the wheels tends to work the spindle nut loose. The nut is often a castellated nut and the nonthreaded fastener is fitted through the slots in the nut and a hole in the spindle. What type of fastener is suitable for this application?

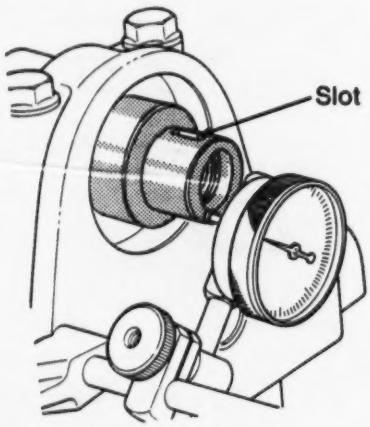
_____

2. The illustration below shows the removal of a nonthreaded fastener used to hold a gear on the shaft. The fastener is inserted through a hole in the gear and through a hole in the shaft. What type of fastener is it?

_____

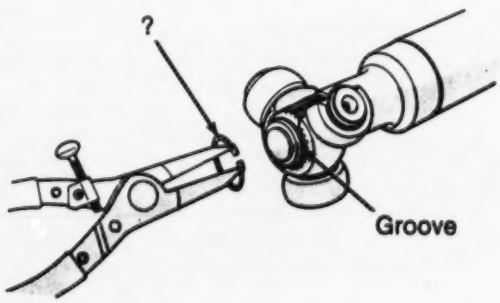


3. The illustration below shows a slot in the camshaft of a Chrysler 2.2L engine. A nonthreaded fastener is used to hold the camshaft sprocket in place on the shaft while a cap screw is threaded into the shaft to secure the sprocket to the end of the shaft. What is the term for the type of nonthreaded fastener used in this application?



Used with permission of Chrysler Corporation.

4. The illustration below shows the installation of a round nonthreaded fastener onto the grooved end of a shaft. The fastener holds the tripod assembly on the driveshaft of a front-wheel-drive vehicle. What is the name of the fastener indicated? Describe the specific fastener shown.



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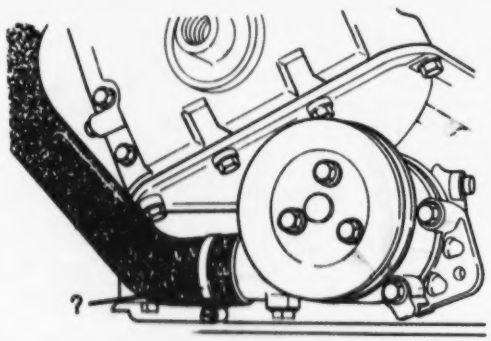
5. In most modern vehicles, a nonthreaded fastener is used to attach the rearview mirror to the windshield. The fastener is designed to release easily in the event of an accident to reduce injury to vehicle occupants. What type of fastener is normally used?

_____

6. The attachment of a radiator hose to the water pump is shown in the illustration below. What type of fastener is used for this application as indicated by the arrow?

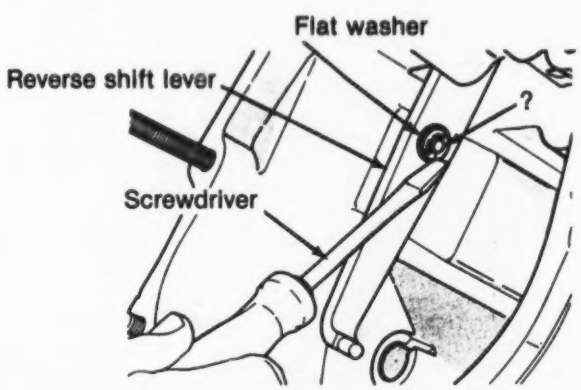
_____



Used with permission of Chrysler Corporation.

7. The illustration below shows the removal of a nonthreaded fastener that is used on one vehicle design to hold the reverse shift lever to the manual transaxle. What type of fastener is it?

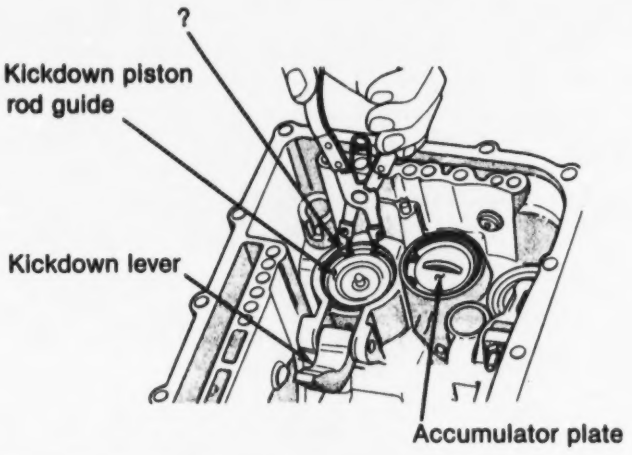
_____



Used with permission of Chrysler Corporation.

8. Removal of a fastener used on one type of automatic transaxle is shown below. What kind of fastener is it? Be specific in your description.

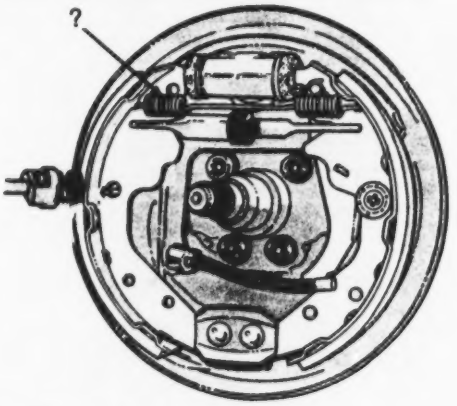
_____



Used with permission of Chrysler Corporation.

9. The illustration below shows a nonthreaded fastener used to hold together the upper ends of brake shoes. What type of fastener is shown?

_____



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10. One type of nonthreaded fastener is used to fasten parts that are not designed to be disassembled. Installation of this fastener involves inserting it through a hole and then deforming the fastener so that it will stay in place. What is this type of fastener called?

_____

11. Some automotive vehicle parts are held together or in place using tension. What type of nonthreaded fastener can be used to hold such parts in place?

_____

12. Clamps are used to hold soft, rubber parts to hard, round connections. There are different types of these clamps, each used for specific applications.

    a. Which of the following clamps would best be suited to connect smaller hoses, such as fuel lines?

_____ Clamp A _____ Clamp B _____ Clamp C

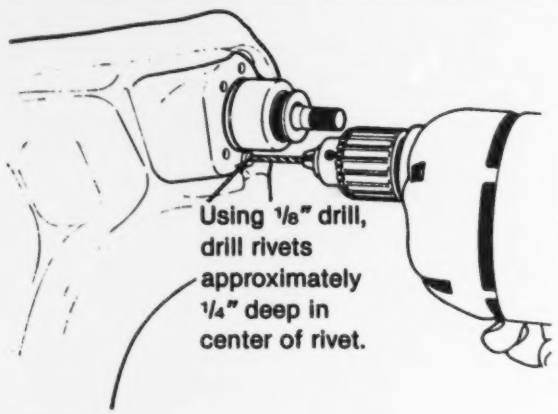
    b. You need to install a cooling system hose. Which of the following nonthreaded fasteners would be suitable for connecting this hose? Mark all that are suitable.

_____ Clamp A _____ Clamp B

_____ Clamp C _____ Clamp D

13. The upper ball joints in the front suspension systems of some rear-wheel-drive vehicles are held in place by a nonthreaded fastener that is not designed for removal during normal use. This fastener is used for upper ball joints because the nature of the forces acting on the suspension system tends to concentrate wear in the lower ball joint. Should replacement of the upper ball joints become necessary, the original fasteners must be drilled out as shown in the illustration below. They are then replaced with nuts and bolts. What is the name of the original nonthreaded fastener?

_____



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ASSIGNMENT SHEET 6

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 8

Select correct tools to use with nonthreaded fasteners

Name _____ Score _____

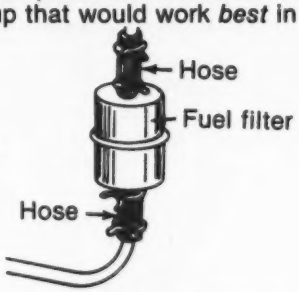
INTRODUCTION

Using the proper tools to remove and install nonthreaded fasteners not only makes the work easier but can also help to ensure that the job is done properly. Because of the variations available in nonthreaded fasteners there are also many variations in the tools used with them. In some cases, more than one type of tool could be used for a given job, though usually there is one tool that is better suited than others. The good service specialist knows how to choose the correct tool and use it properly. This assignment sheet will give you practice in selecting the correct tools to use with nonthreaded fasteners.

DIRECTIONS

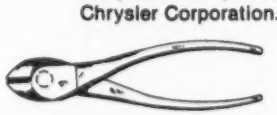
Read Student Supplement 7, "Tools Used to Remove and Install Nonthreaded Fasteners," and then read the situations described below and on the following pages. Each situation describes the installation or removal of a nonthreaded fastener and then offers a choice of tools for performing the required procedure. Write an "X" in the blank before the tool in each group that would work *best* in doing the required job.

1. Which of the tools below is best suited for removing the hose clamps shown in the illustration at the right?



Adapated with permission of Chrysler Corporation.

_____ Tool A

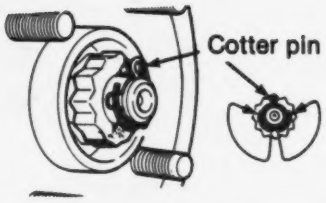


_____ Tool B

_____ Tool C

_____ Tool D

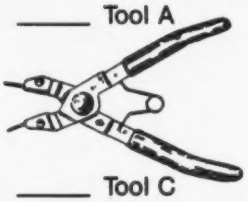
2. The illustration at the right shows a cotter pin installed in a wheel spindle. Which of the tools below would do the best job of removing the cotter pin?



Used with permission of Chrysler Corporation.

_____ Tool A

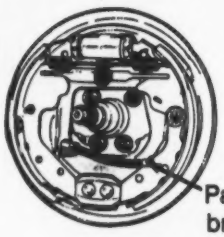
_____ Tool B



_____ Tool C

_____ Tool D

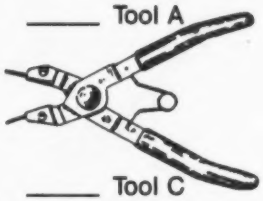
3. The illustration at the right shows the parts of a drum brake assembly. You need to disconnect the parking brake cable from the parking brake. Which of the tools below should be used to remove the spring?



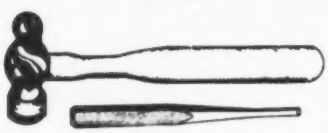
Used with permission of Chrysler Corporation.

_____ Tool A

_____ Tool B



_____ Tool C



_____ Tool D

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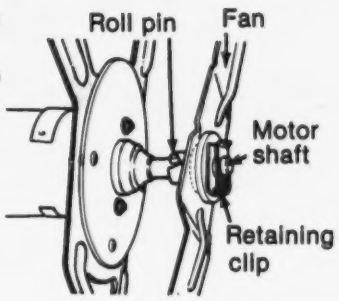
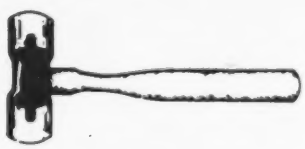
4. The retaining clip in the illustration at the right holds a radiator fan in place. What tool should be used to remove it?



Used with permission of Chrysler Corporation.

_____ Tool A

_____ Tool B



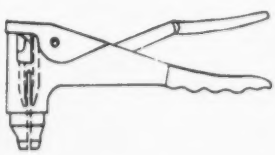
_____ Tool C

_____ Tool D

5. A roll pin is also indicated in the illustration above. Which of the tools shown below should be used to remove the roll pin?

_____ Tool A

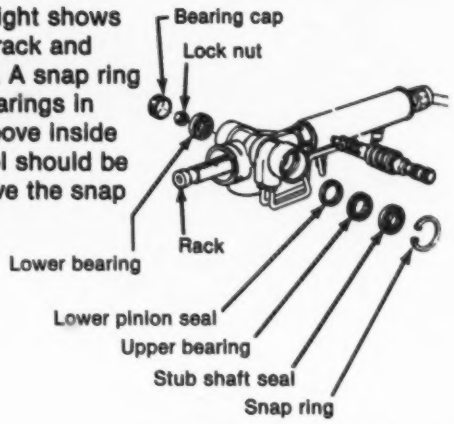
_____ Tool B



_____ Tool C

_____ Tool D

6. The illustration at the right shows an exploded view of a rack and pinion steering system. A snap ring holds the seals and bearings in place by fitting in a groove inside the housing. Which tool should be used to install or remove the snap ring?



Used with permission of Chrysler Corporation.

_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

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ASSIGNMENT ANSWERS

REMOVE AND INSTALL COMMON FASTENERS

ASSIGNMENT SHEET 1

PART A

1. Set screw
2. Slotted or castellated
3. Stud
4. Metal screws
5. Cap screw: Illustration A
   Hex bolt: Illustration B
6. Wing nut
7. Self-tapping screw
8. Between the nut and the part
9. Couplings
10. Locking washer

PART B

1. Diameter = 1/4 inch
   Length = 1 inch
2. Diameter = 8 millimeters
   Length = 24 millimeters
3. Illustration C
4. **Fastener A**
   Length = 1 1/2"
   Diameter = 1/2"
   Fastener B
   Length = 28 mm
   Diameter = 10 mm

PART C

1. Fastener A, Fastener B
2. **Group A**
   a. 2
   b. 3
   c. 1
   Group B
   a. 3
   b. 1
   c. 2
3. a. U
   b. C
   c. C
   d. U

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PART D

1. a. Fine
   b. Coarse
   c. Extra fine
2. Studs usually have coarse threads on one end and fine threads on the other end

PART E

1. a. Metric
   b. 30 mm
   c. 2.00 mm
   d. 10 mm
   e. 5.8
2. a. U.S.
   b. 5/8"
   c. 1 1/2"
   d. 18
   e. 5
3. a. U.S.
   b. .190"
   c. 1"
   d. 24
   e. 2A
   f. 2
4. a. U.S.
   b. 7/16"
   c. 1 1/8"
   d. 14
   e. 5

ASSIGNMENT SHEET 2

1. If screw is not rusty or damaged and develops required torque before it seats
2. Fastener C
3. Fastener B, Fastener D
4. Fastener B
5. Fastener B, Fastener C
6. Fastener A, Fastener B
7. a. 10
   b. 12
8. d
9. Stud A, Stud B
10. Self-tapping

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ASSIGNMENT SHEET 3

1. Tool C
2. Tool B, Tool D
3. Tool C
4. Fasteners that have broken off below the surface
5. Tool B
6. Tool C
7. Tool A
8. Tool A

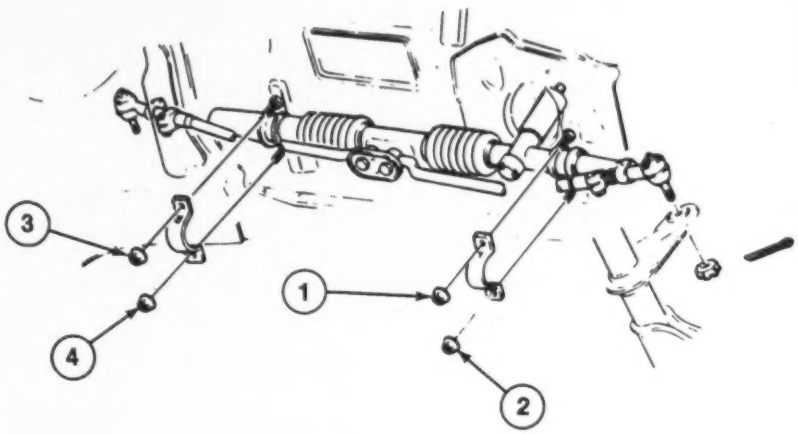
ASSIGNMENT SHEET 4

PART A

1. Corners
2. Seat fully
3. Clean; inspect
4. Hand-start
5. Pull; push

PART B

1. a. With wheel rotating, torque nut to 17-25 ft lbs
   b. Back nut off one-half turn
   c. Tighten adjusting nut to 10-15 in lbs
2. No; must reach 18 ft lbs
3. One washer plate must be discarded; one bolt must be discarded and replaced
4.



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

5. The four that are almost 4 9/16" long must be discarded

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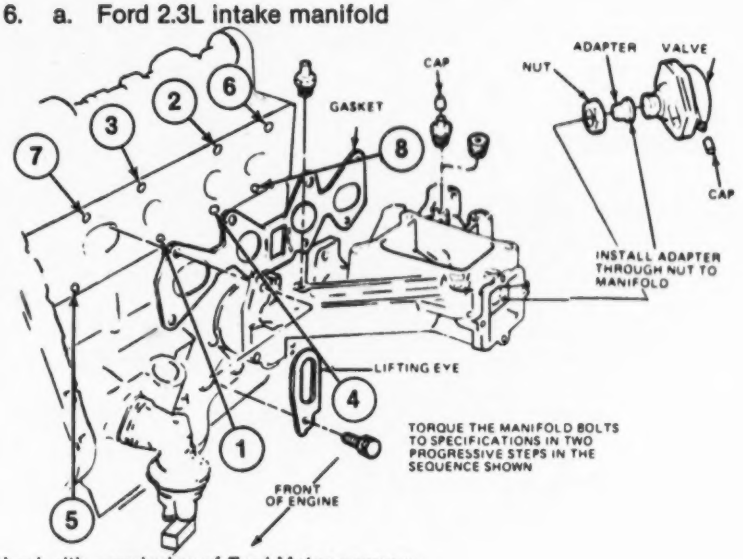
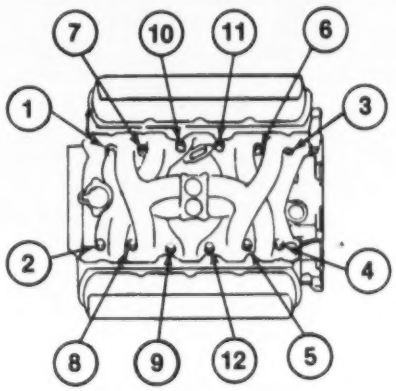
6. a. Ford 2.3L intake manifold



Used with permission of Ford Motor company.

b. GMC 307 CID cylinder head bolts



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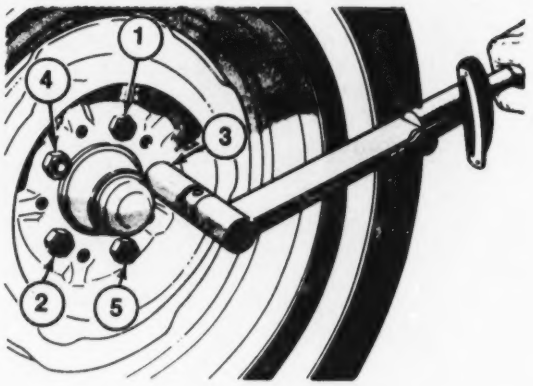
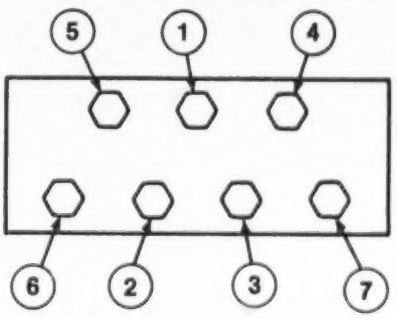
c. Chrysler five-bolt wheel lugs



Used with permission of Chrysler Corporation.

d. AMC 151 CID exhaust manifold



From *Chilton's Auto Repair Manual 1985,* Chilton Book Company, Radnor, PA.

7. a. 35 ft lbs
   b. 200 in lbs
   c. 11-13 ft lbs
   d. 7-9 ft lbs
8. a. Engine oil
   b. Engine oil
   c. Waterproof sealer

ASSIGNMENT SHEET 5

1. Cotter pin
2. Roll pin
3. Key
4. External snap ring
5. Adhesive
6. Hose clamp
7. External snap ring—E-type
8. Internal snap ring
9. Spring
10. Rivet
11. Spring
12. a. Clamp C
    b. Clamp A, Clamp B
13. Rivet

ASSIGNMENT SHEET 6

1. Tool D
2. Tool A
3. Tool B
4. Tool A
5. Tool D
6. Tool C

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JOB SHEET 1

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 9

Inspect and replace air filter

INTRODUCTION

The internal combustion engine used in most vehicles works by burning a mixture of fuel and air. The fuel and air are mixed in the carburetor or the fuel-injection system. The fuel comes from the fuel tank while the air is just taken from the atmosphere surrounding the vehicle. Most people have no idea how much air is actually passed through the engine of a car, but it is a tremendous amount. The most efficient mixture for a gasoline engine is 14 to 15 parts of air for every part of fuel by weight. Thus, for every gallon of gasoline that an engine burns, it gulps in approximately 1000 gallons of air. That means that a vehicle getting 25 miles per gallon of gasoline will use 40 gallons of gasoline and 40,000 gallons of air in driving 1,000 miles. Since the air comes from the atmosphere, it is full of smoke, dust, pollen, insects, and the other particles that fill the air around us. These *contaminants*, or unwanted substances, reduce the efficiency of the burning process in the engine and lead to increased wear and quicker breakdown of the parts involved in delivering and burning the fuel-air mixture.

As a result, air entering the carburetor or fuel-injection system is filtered to remove floating particles. Filtration is generally done by forcing the air to pass through a fine material that traps the particles in the air. Materials used in automotive air filters include paper, wire or plastic mesh, cellulose fiber, polyurethane foam, and combinations of these materials. Some designs even use an oil reservoir from which oil droplets are pulled by the moving air. The oil helps to trap particles and wash them from the filter.

Air filters must be cleaned or replaced when they become clogged with particles to the point that not enough air gets through to mix with the fuel. Filters must also be replaced whenever they become damaged so that particles get through them or unfiltered air passes around them. All vehicle manufacturers suggest how often air filters in their vehicles should be cleaned or replaced. However, the actual need for cleaning and replacement will depend on a number of factors, such as how the vehicle is driven, the roads over which it is driven, the kind of weather in which the vehicle is driven, and many others. For example, air filter service will be required more often than suggested by the manufacturer if the vehicle is driven primarily over dirt roads in dusty conditions. The only way to know for sure is to check the filter periodically.

The procedures for cleaning filters vary with the filter material and manufacturer. For example, some manufacturers recommend blowing compressed air through the filter from the inside, while others believe that paper cleaners cannot be reused. Foam and fiber filter elements may be cleaned in special solvents following the manufacturers recommendations, while in other cases these types are simply replaced.

Whether cleaning or inspecting air filters, you should follow some general guidelines for any type of filtration system.

- Always clean the filter housing, wiping it with a lightly oiled cloth and using care not to get any contaminants in the carburetor or injector air intakes.
- Make sure that all gaskets—those on filter elements and on housing covers—are in good condition and make an airtight seal; be careful not to damage the gaskets while servicing the filter.

While inspecting, cleaning, and replacing air filters, you will encounter a number of fasteners. Many designs use wing nuts, hex nuts, and various types of bolts and threaded studs. A number of manufacturers use clips to hold housing covers in place. This job sheet will give you practice working with these different fasteners while inspecting and replacing an air filter.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped.

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JOB SHEET 2

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 10

Replace PCV valve

INTRODUCTION

When the piston moves up in the cylinder to compress the fuel-air mixture prior to combustion, some of the gases in the combustion chamber are forced past the piston rings. These gases that escape into the crankcase are called *engine blowby*, and they present two serious problems. First, they contain acid and sulfur and small amounts of water. These substances corrode engine parts, break down engine oil, and form a thick, sticky material called *sludge* that interferes with engine operation. At one time, vehicles were equipped with engine blowby draft tubes. The draft tube allowed engine blowby gases to be pulled from the crankcase as the vehicle drove down the road. But this led to another problem with engine blowby: it adds to air pollution because, besides the sulfur and acid, it also contains some unburned fuel and carbon monoxide.

To prevent the release of pollutants into the air, automobile manufacturers began using a system called *positive crankcase ventilation* (PCV). In a PCV system, engine blowby gases are pulled out of the crankcase and directed into the intake manifold to become part of the engine combustion mixture. Early PCV designs were open and allowed blowby gases to escape from the system when the engine was shut off. This, of course, added to air pollution, and today's vehicles use a closed crankcase ventilation system.

An important part of the PCV system is a valve that adjusts the flow of air through the system for various engine operating conditions. This allows the engine to run on a proper mixture of air and fuel whether it is idling, cruising, or accelerating. The PCV valve also prevents the engine blowby fumes in the crankcase from igniting in the case of *backfire*. Backfire occurs when the combustion gets out of hand and the air-fuel mixture in the intake manifold ignites. You've probably heard the loud pop of a car backfiring. The PCV valve does not allow reverse flow, thus stopping backfire ignition from continuing into the PCV system and the crankcase. Operation of the PCV valve is shown in Figure 1 on next page.

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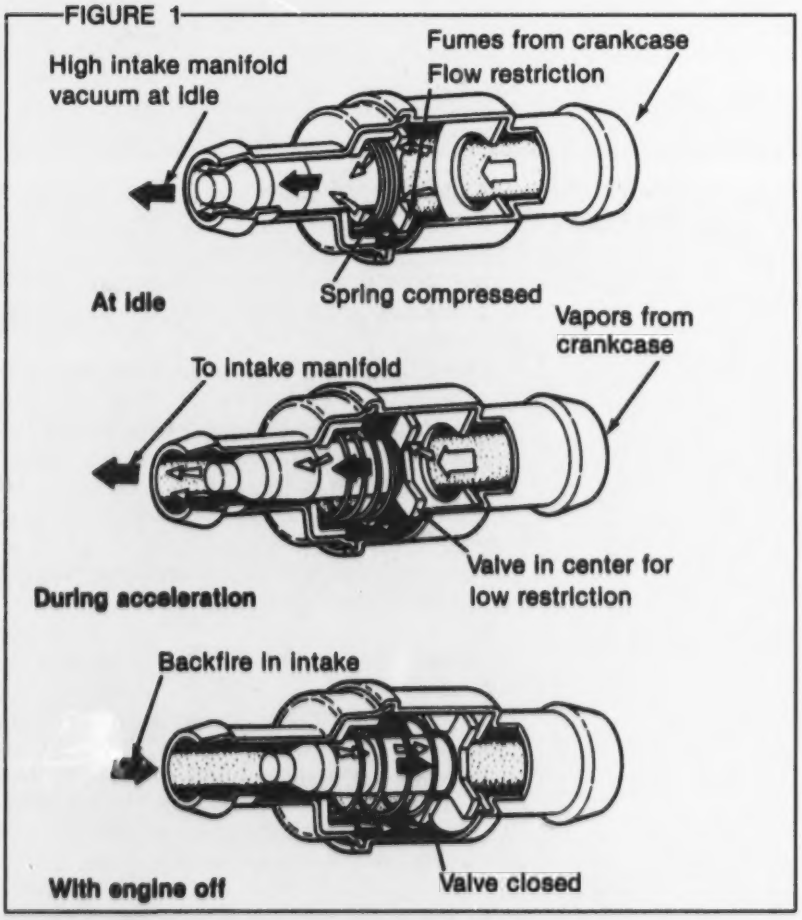
FIGURE 1



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PCV valves can stick open or closed, become clogged by oil and particles passing through them, or otherwise become defective. Generally, there is no service that can be done to the valve, and it is simply replaced when defective. There are several tests that can be performed to check PCV valve operation, and one is described in this job sheet. There are some guidelines that should be followed when inspecting this system and replacing the PCV valve, and these are listed below.

- Be sure to check the hoses to see that they are properly connected and not badly cracked or split.
- Check the PCV filter that is generally located in the air cleaner housing.
- Always use exhaust-removal equipment whenever an engine is running in the shop.

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PCV valves and components are connected using various fasteners—usually clamps and clips. This job sheet will allow you to practice removing and installing those fasteners and will acquaint you with the procedures used to test and replace a PCV valve.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: PCV valve testers are available; however, the following procedure will allow you to determine if the valve is operating.

1. Study PCV valve removal procedure in service manual
2. Install exhaust-removal equipment if procedure is to be performed in the shop
3. Idle engine until it reaches normal operating temperature
4. When vehicle reaches normal operating temperature, disconnect engine side of PCV valve
5. Listen for hissing sound from valve
6. Place your finger over the opening:
   a. *If* you feel suction and engine slows down, continue procedure to see if valve is operating correctly
   b. *If* there is no suction, replace valve following service manual procedures and repeat test; *if* there is still no suction, lines are probably clogged and should be cleaned in accordance with manufacturer's procedures
7. Reconnect engine side of valve
8. Remove crankcase inlet-air cleaner
9. Remove crankcase oil filler cap on valve cover
10. Hold a sheet of notebook or typing or similar-size paper approximately 1 inch above valve cover opening
11. After a few seconds, paper should be pulled against opening:
    a. *If* paper is **not** pulled to opening, there is a clog in engine side hoses or connections; clean hoses and repeat test
    b. *If* paper is pulled to opening, continue procedure

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12. Turn off engine

13. Remove PCV valve and shake it:

    a. *If* PCV valve rattles, it may be operating correctly; continue procedure

       NOTE: A valve that rattles may not necessarily indicate a good valve. The spring inside the valve that is calibrated for the system may have become weak, and therefore it would not close the valve when it should, thus causing oil consumption. If the valve is old or shows signs of being heated, it is best to replace it.

    b. *If* PCV valve does **not** rattle, replace it and repeat test

14. Reinstall PCV valve, oil filler cap, and crankcase inlet-air cleaner

15. Remove exhaust-removal equipment if used

16. Have instructor evaluate your work

17. Clean work area and return equipment and materials to proper storage

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JOB SHEET 3

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 11

Replace fuel filter

INTRODUCTION

Vehicles are equipped with one or more devices that filter the fuel to prevent contaminants from reaching the carburetor or injectors. Most manufacturers specify service intervals for fuel filters, but these, of course, may vary for different driving conditions and even with the quality of fuel used. Indications of a clogged fuel filter include various types of fuel starvation—that is, the engine stops or runs roughly due to insufficient fuel. A filter may fail suddenly, causing the vehicle to stop completely at any speed. However, a more common indication of fuel filter clogging is sputtering or engine shutdown at higher speeds or during heavy acceleration. Under these operating conditions, the engine has a higher demand for fuel, and a partially clogged filter may give the above indications. Other malfunctions may also lead to fuel starvation, including clogged in-tank strainers, faulty fuel regulators, misoperating fuel pumps, clogged fuel injectors or carburetor needle valves, or defective carburetor or injector operation. For that reason, replacing the fuel filter is an easy approach to solving fuel starvation problems, but be prepared to look for other causes if the condition still exists after replacing or cleaning the filter.

The service specialist must be aware of a number of guidelines when servicing fuel filters or other components of the fuel delivery system. Most important is the danger of fire and explosions whenever fuel is involved. Along that same line are the hazards involved in breathing fuel vapors and having fuel contact your skin and eyes. Another health hazard to be avoided is the common practice of starting a siphon of fuel by sucking on a fuel line. This can lead to inhaled fuel and probable pnuemonia or swallowed fuel, leading to digestive problems or poisoning.

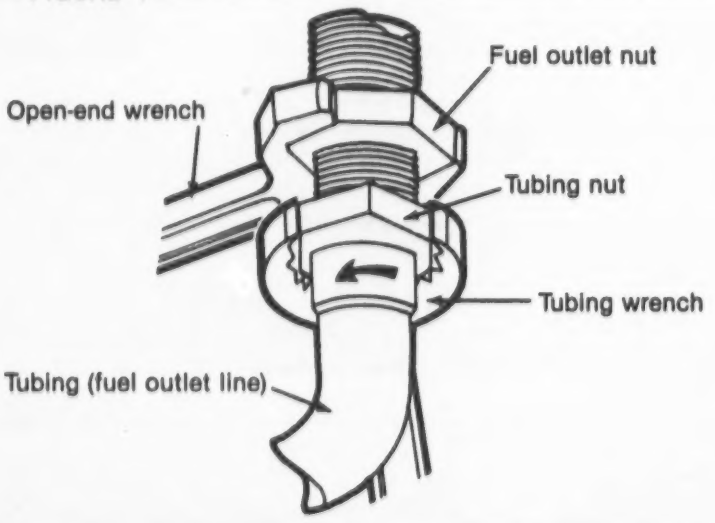
These conditions require great care in handling fuel and the fuel system; therefore, always follow the guidelines listed below and on the following page.

- Never open fuel lines or handle or store fuel around flames, sparks, or heat sources.
- Plug fuel lines as soon as possible and clean up any fuel that spills or leaks; dispose of fuel-soaked rags properly and immediately.
- Change fuel-soaked clothing immediately.

- Repair any fuel leaks immediately.
- Follow the manufacturer's instruction for relieving pressure in fuel-injected systems because these systems are under high pressure and can spray fuel over a wide area if pressure is not relieved.
- If fuel lines must be rerouted, be sure that they are secured and located away from heat sources.
- Use only approved hose, clamps, and lines for fuel delivery.
- Be sure that all hoses and connections are fully seated and secured.
- After any service to the fuel system, check the entire system for leaks with the engine running and with the engine stopped.
- Use an acceptable replacement filter or element to ensure proper filtration and adequate fuel supply.

Another consideration in working with fuel lines is the need to use proper tubing wrenches and techniques when connecting and disconnecting fuel lines, as shown in Figure 1. Otherwise, lines may be twisted or kinked.

FIGURE 1



From *Engine Tune-Up Service, Unit 5: Fuel and Carburetion Systems*, 2nd ed., © 1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

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So, although the replacement of a fuel filter is a fairly simple task, there are many concerns that the service specialist must keep in mind while performing the procedure. This job sheet will give you practice in using the correct fasteners and tools while replacing a fuel filter.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped.

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JOB SHEET 4

REMOVE AND INSTALL COMMON FASTENERS

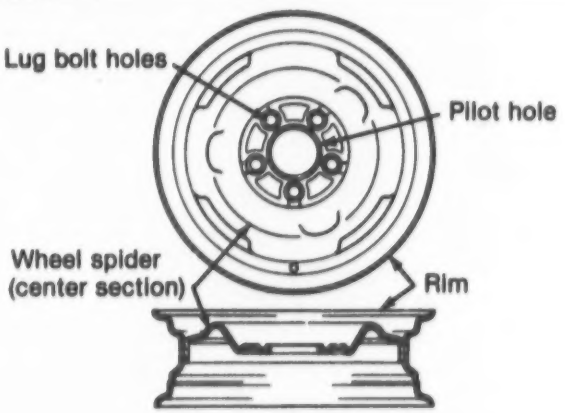
OBJECTIVE 12

Remove and reinstall tire-and-wheel assemblies

INTRODUCTION

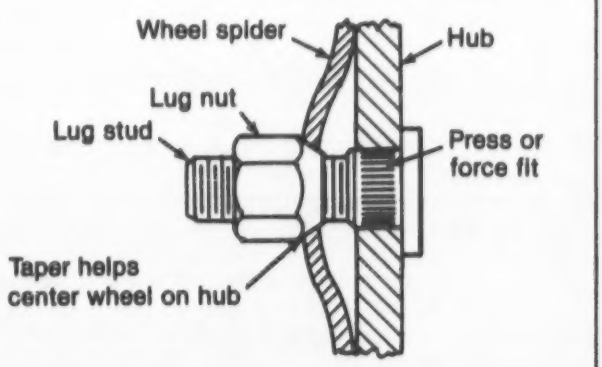
The vehicle rides on the tire-and-wheel assemblies. Each assembly consists of the wheel, the tire, and the wheel cover. The tire is mounted to the wheel by being fitted inside the rims of the wheel and filled with air. A wheel is shown below in Figure 1.

FIGURE 1



Used with permission of Chrysler Motors Corporation.

FIGURE 2



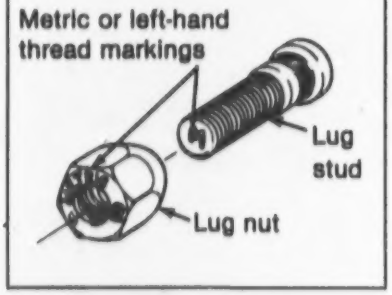
Courtesy Cadillac Motor Car Division, General Motors Corporation.

The wheel is secured to the hub rotor at the end of the axle or spindle. The pilot hole slides over the wheel bearing dust cap or hub center, and then the wheel is secured by means of lug nuts or lug bolts. When lug nuts are used, the wheel hub has a number of lug studs—usually 4, 5, or 6—that match the lug bolt holes in the wheel. The wheel is installed over the lug studs, and a lug nut is threaded onto each stud to hold the wheel in place. One end of the lug nut is tapered to fit into the tapered hole in the wheel (see Figure 2). This helps to center the wheel.

Lug bolts work in much the same way. The lug bolt goes through the hole in the wheel and threads into a tapped hole in the hub. The head of the bolt is tapered to the shank in the same way the lug nut is tapered.

On some vehicles left-handed threads are used on the left side of the vehicle while right-handed threads are used on the right side. This is done so that the forward rotation of the wheel tends to tighten the fasteners rather than loosen them. Left-handed threaded lug fasteners and metric lug fasteners are generally marked as shown in Figure 3 below.

FIGURE 3



Courtesy Cadillac Motor Car Division,
General Motors Corporation.

The most important considerations in the installation of tire-and-wheel assemblies are that the wheel be correctly seated on the hub and that the lug fasteners be correctly threaded and torqued.

Wheels themselves come in a variety of designs and are made of various material. Aluminum and magnesium are frequently used in the manufacture of sporty wheel designs and are commonly called *mags*. These softer materials may require special handling, and you should refer to the vehicle or wheel manufacturer's instructions. The procedures included here are generally true for steel wheels, but may not be correct for mags and other special wheels.

Wheel covers, too, are available in many designs. The primary purpose of wheel covers is to improve the appearance of the wheels by hiding lug fasteners, dust caps, and wheel hubs, although most wheel covers do provide some protection against dirt, water, and other substances that might damage the wheel, hub, or fasteners.

Service of many components besides the tire-and-wheel assembly require its removal, including some wheel, brake, steering, suspension, transmission, and even engine service. In addition to the planned service, you should make the following inspections whenever a tire-and-wheel assembly has been removed:

- Check the tire and wheel for damage, distortion, and separation.

- Check the lug fastener threads and their fit in the correct wrench.
- Check components that are normally hidden by the tire-and-wheel assembly, including hub rotor, brakes and brake lines, suspension and steering parts, shock absorbers, and body parts.

This job sheet covers the general process for removing and installing a typical steel wheel using hand tools. Later you will learn to use power tools for the same procedure. You will also learn in later job sheets how to dismount, repair, and mount tires.

EQUIPMENT AND MATERIALS

- Torque wrench and socket
- Lug wrench
- Pry bar if lug wrench is not so equipped
- Hydraulic lift or jack and jack stands
- Rubber hammer

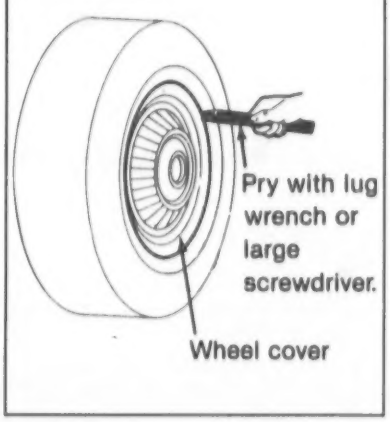
PROCEDURE

To remove tire-and-wheel assembly

1. Remove wheel cover and set it aside where it will not get damaged or be in the way (Figure 4)

   NOTE: Some wheel covers require the use of screwdrivers or wrenches for removal, but most can be removed simply by prying them loose.

FIGURE 4



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2. Loosen lug nuts or bolts a few turns

   NOTE: This is done prior to raising the vehicle so that the weight of the vehicle will keep the wheel from turning and to avoid putting strain on drive axles.

   CAUTION

   If lug fasteners are difficult to turn, refer to the vehicle manufacturer's recommended procedures for loosening them. Also, check the fastener and the service manual to make sure of the hand of the fastener threading. Do **not** use heat or penetrating oil on aluminum or magnesium wheels.

3. Raise vehicle and support safely

4. Remove lug fasteners, using care **not** to allow tire-and-wheel assembly to slip off hub

5. Remove tire-and-wheel assembly and set aside where it will not get damaged or be in the way

6. Store lug fasteners with wheel cover

7. Continue with required service procedure

PROCEDURE

To reinstall tire-and-wheel assembly

1. Slide wheel onto hub with bolt holes over lug studs or aligned with threaded holes in hub

   CAUTION

   Use care **not** to damage threads on lug studs.

2. Start lug fasteners by hand, making certain that fasteners are threaded correctly

3. Tighten lug fasteners

   a. Refer to service manual to determine tightening sequence and correct torque

   b. Tighten first fastener until it makes contact with wheel

   c. Tighten other fasteners in sequence, keeping fasteners even as wheel moves toward hub

   d. As wheel makes contact with hub, check tapered section of fasteners to be sure that fasteners are centered in holes

e. Pull wheel snug and flat against hub by tightening each fastener in sequence until snug

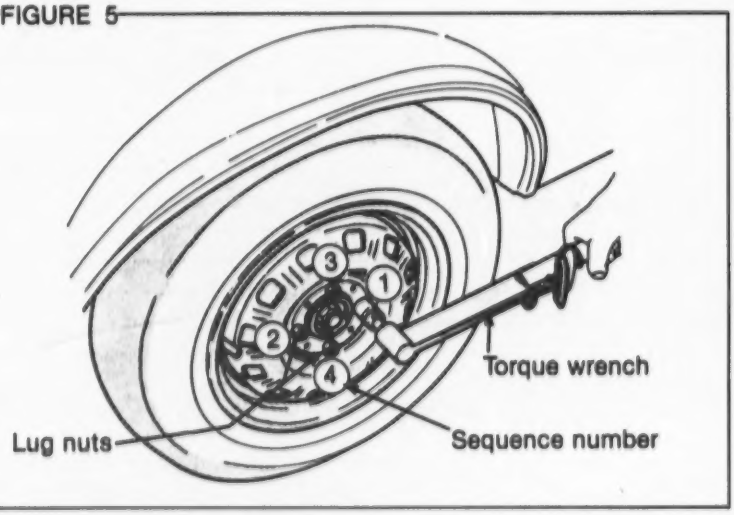
f. Repeat tightening sequence to see that all fasteners are snug

4. Lower vehicle

5. Torque lug fasteners to manufacturer's specifications

a. Tighten each fastener to required torque in recommended sequence (Figure 5)

FIGURE 5



Used with permission of Chrysler Corporation.

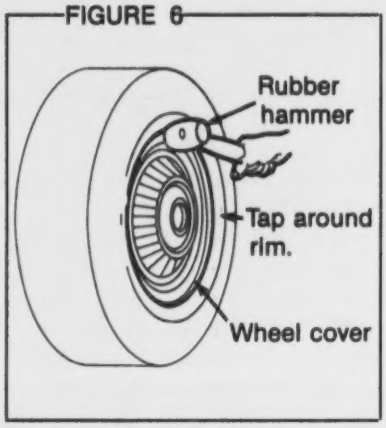
b. Repeat tightening sequence to be sure each fastener is correctly torqued

6. Reinstall wheel cover

a. Align wheel cover on wheel being sure that valve stem passes through valve stem hole in cover, if so equipped, and that holding prongs or other features are engaged

b. Start at one side and lightly tap around edge of wheel cover with rubber hammer, slowly engaging holding devices completely around wheel cover (See Figure 6)

FIGURE 6



Used with permission of Florida Department of Vocational Education.

c. Continue light taps around wheel cover until it is completely seated

NOTE: If the wheel cover will not seat, remove it, and realign it. If it still will not seat, check for damage and repair or replace as necessary.

d. Check to see what wheel cover is properly attached by visually inspecting entire edge of wheel cover

7. Have instructor evaluate your work

8. Clean work area and return equipment and materials to proper storage

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JOB SHEET 5

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 13

Remove and install hoses

INTRODUCTION

Many automobile systems use hoses. Although hoses are designed for specific uses, they eventually clog, develop leaks, or show other defects that require their replacement. The most important guideline in replacing hoses is to use the right hose for the job to be done. It must be the right size hose of the proper construction to withstand the temperatures, pressures, and substances with which it will be used. When replacing hoses, use those that meet or exceed standards of the original equipment. When replacing vacuum hoses, you should try also to match the color coding of the original hose to avoid conflict with vacuum diagrams. Other guidelines are listed below.

- Follow the vehicle manufacturer's instructions exactly, especially for high-pressure hose which can be very dangerous.
- Additional procedures may be required for some systems because disconnecting a hose will introduce air into the system; this is especially true of power steering, fuel injection, air conditioning, and brake systems.
- Follow those guidelines and precautions that apply to the fluids and substances carried by the hose being serviced; for example, for fuel lines follow the guidelines given in Job Sheet 3, for brake lines do not allow brake fluid to come in contact with painted surfaces, etc.
- Use the correct fasteners, and use the proper tools and techniques to install them.
- Use sealants where prescribed by the vehicle manufacturer.
- Be sure that clamps are straight and behind raised beads where applicable.
- Do not overtighten worm-drive or band clamps as this may damage the hose or the fitting; be especially careful of the many plastic parts used on the radiators of newer cars.
- Do not twist hoses or bend them too much as this may restrict flow.
- Always check connections with and without the system operating.

Whenever you service a vehicle and have a chance to check hoses, especially, when servicing a system that has hoses, inspect the hoses and hose connections in the area. Some failures such as broken or split hoses are fairly obvious. Leaks around connections may be fairly apparent. Other failures may be more difficult to spot. Look at the hose to see if it appears swollen or stretched. Check the ends for signs of hardening, softening, or chafing. Try moving the hoses near connections and look for cracks or splits. Also, look for exposed fittings from which hoses may have been disconnected.

Besides a visual inspection, you should also try squeezing some hoses. This will indicate whether the hose has hardened, collected corrosion inside, or has weakened.

Finally, many of the defects that occur in hoses occur at their ends at the point of connection. For some soft flexible hoses it may be possible to simply trim off the defective end and reconnect the hose. Be sure, however, that the rest of the hose is in good condition, that a good connection can be made, and that repositioning the hose does not twist, stretch, or kink it.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped.

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REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 14

Inspect and replace shock absorbers

INTRODUCTION

The service life of a shock absorber depends on the shock absorber and the conditions under which the vehicle is used. Rough roads and heavy loads will shorten the effective life of a shock absorber. Under ideal conditions, a shock absorber may give 50,000 miles (84,000 kilometers) or more of safe, reliable service. However, even then the performance of the shock absorber has probably decreased a great deal. As with many automotive components, the changes in ride and handling caused by weak shocks, build gradually and may not be noticed by the driver until they get very severe or lead to a more sudden change, such as a shock absorber that has come loose from its mounting bracket. For this reason, shock absorbers should be inspected whenever other service makes it convenient to check them. After about 20,000 miles (34,000 kilometers), they should be checked every 5,000 miles (7,000 kilometers), and more frequently as the age of the shock increases. This job sheet describes how to inspect shock absorbers and replace them when required. This procedure applies to conventional hydraulic shock absorbers. Inspection and replacement of air shocks and automatic leveling systems is covered in *Steering and Suspension Specialist*.

There are basically three things that can go wrong with a shock absorber. Hydraulic fluid can drain from the shock absorber due to a poor seal. The internal parts of the shock absorber may become weak or worn. Physical damage or wear can occur in the shock absorber or its mounting hardware. In the first two instances, the shock absorber must be replaced. The shock will also need to be replaced if the dust shield, pressure tube, or mountings have been damaged. In the case of loose, worn, or damaged mounting hardware, the shock may still be usable. In some instances, the hardware can be tightened and returned to normal operation.

However, in many cases, the vibration caused by the loose hardware will accelerate wear of the parts. When mounting hardware is worn, the correct repair technique will depend on the extent and the nature of the wear. For example, elongated or oval worn holes are fairly common in some mounting designs.

In these instances, it may be possible to change fasteners and salvage the bracket and shock. In other cases, the bracket may require repair through welding or replacement.

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When replacing shock absorbers, several questions should be asked of the customer in selecting the right shocks. First, are heavy-duty shock absorbers or overload shocks a good idea? Heavier replacement shocks may especially be advised if the previous shock absorbers wore out with fairly low mileage, if the driving conditions of normal use have changed to rougher roads or heavier loads, or if the vehicle had high mileage, meaning worn suspension system components.

The service specialist should be aware, too, that replacement shocks are not made to custom-fit every make and model of vehicle. Thus, a replacement shock may require modification to the vehicle mounting bracket or the use of a bushing or other hardware to fit a specific vehicle properly. The service specialist should read and follow the instructions that come with the shock absorber.

Shock absorbers should always be replaced in pairs, except in a unique situation such as seal failure on a vehicle with very low mileage. Otherwise, the failure to replace both front shocks or both rear shocks together will lead to an uneven ride and possibly to dangerous differences in the side-to-side handling of the vehicle. In most cases, when one shock absorber wears out internally, the others should also be replaced. The replacement procedure can often be speeded by using penetrating oil on the shock absorber fasteners.

Finally, many vehicles today are equipped with strut systems instead of shock absorbers, particularly at the front wheels. These struts require special knowledge and service procedures, which are covered in *Suspension and Steering Specialist*.

This job sheet will give you practice in inspecting and replacing conventional hydraulic shock absorbers.

EQUIPMENT AND MATERIALS

- Hydraulic lift or jack and jack stands
- Basic hand-tool set

PROCEDURE

To test shock absorbers

1. Park vehicle on hard, level surface
2. Put transmission in PARK if equipped with automatic transmission or in gear if equipped with a manual transmission
3. Stand at one corner of vehicle
4. Place one hand on bumper or fender and other hand on hood; press down as far as you can (See Figure 1)

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FIGURE 1

5. Keeping hands on vehicle, allow vehicle to come back up, and then press down again
6. Repeat steps 4 and 5 until that corner of vehicle is bouncing up and down
7. Release vehicle when you have pushed it all the way down
8. Observe vehicle as it comes to rest
   a. *If* vehicle goes back up and then settles to level, shock absorber is functioning well
   b. *If* vehicle rebounds twice, the shock has worn but is serviceable if it passes a visual inspection
   c. *If* vehicle rebounds more than twice, shock is definitely worn and should be replaced
9. Repeat steps 4 through 8 at each corner of vehicle

PROCEDURE

To inspect shock absorber

1. Raise vehicle so that wheel is off ground and full weight of suspension pulls shock to its full length
2. Check for signs of oil or dirt-coated oil at top and sides of reserve tube (See Figure 2)

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FIGURE 2

3. Check for signs of damage to shock absorber tubes and mounting hardware

4. Grasp shock in your hand, and try to move it up and down and twist it from side to side (Figure 3)

FIGURE 3

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5. Check bushings, rubber grommets, and mounting hardware for visual indications of wear

   NOTE: It may be necessary to clear dirt and rust away to detect some damage or wear.

6. *If* shock absorber shows signs of leakage, worn bushings, or damage, it should be replaced

   NOTE: You may also want to consider the results of the bounce test in deciding whether to replace a shock absorber. If the shock shows some wear and was just acceptable on the bounce test, it may be a good idea to replace the shock. As with all repairs, the service specialist should provide the customer with an honest and thorough explanation of the situation, and allow the customer to make the decision.

7. *If* mounting hardware is damaged or worn, it should be repaired or replaced

   NOTE: If welding is required, refer the service to a qualified welder.

8. Repeat inspection procedures for remaining shock absorbers

   NOTE: Remember that the number of shock absorbers will vary from vehicle to vehicle. Some vehicles have none, while others may have two shocks and two struts. Many vehicles will have one shock absorber at each wheel. Others, such as those with independent front I-beam suspensions, may have six or more shock absorbers.

PROCEDURE

To replace shock absorber

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped and to shock absorber manufacturer's instructions.

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JOB SHEET 7

REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 15

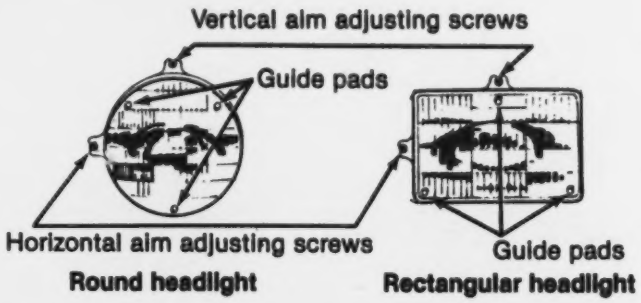
Aim headlights

INTRODUCTION

Headlights are essential for night driving and driving during periods of low visibility. But in order to provide the greatest visibility, headlights must be pointed along the road and ahead of the vehicle. They cannot illuminate the road too near the vehicle, or the driver could only travel at a few miles per hour and still be able to stop within his or her range of vision. The headlights should not be aimed too high or the driver will not be able to see what lies ahead of the vehicle. Additionally, if the headlights point too far to the left, they may blind oncoming drivers. Any of these conditions can lead to a serious accident.

To make sure that headlights are properly adjusted, they are designed so that they can be aimed. Generally, this is done by tightening or loosening screws that rotate the headlights up or down and to the left or right as shown in Figure 1.

FIGURE 1



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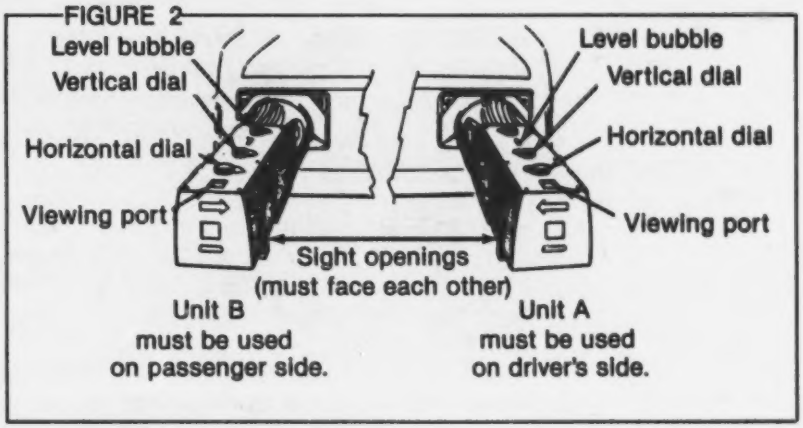
There are common methods for checking and adjusting the aim of headlights. One of these is the use of mechanical aimers. The devices are attached to each headlight and aligned on raised buttons on the lenses of headlights as shown in Figure 2 on the next page. Another type works on a similar principle, but rather using levels or other mechanical devices, the aim of the headlight is checked by lenses and other optical devices. The specific instructions for such instruments are provided by the manufacturer, and your instructor will demonstrate the use of aiming devices available in your shop.

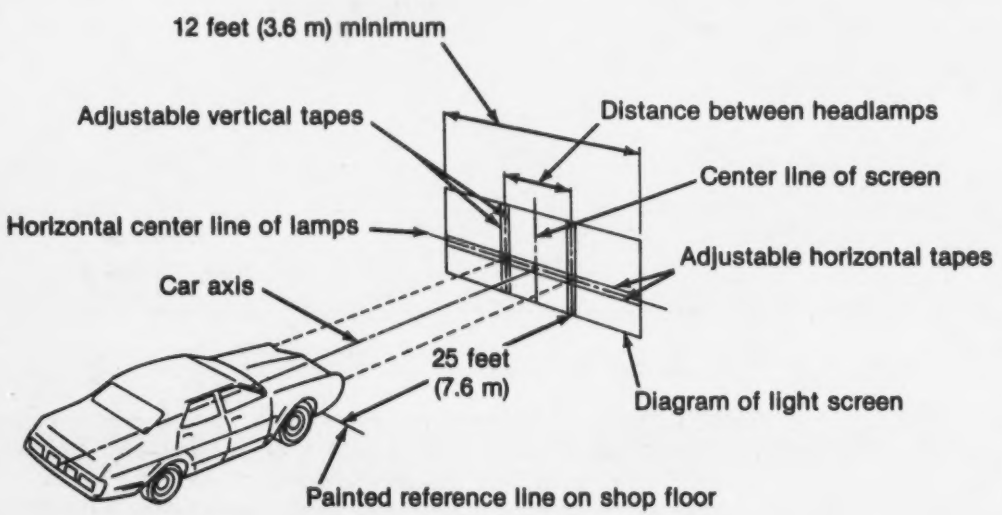
FIGURE 2



Used with permission of Chrysler Corporation.

The other method for aiming headlights is the use of a screen onto which the headlights are directed. This type of screen is shown below in Figure 3. The vehicle is set at a specific distance from the screen with the lights on. Lines on the screen let the service specialist know where the headlight beams should hit the screen.

FIGURE 3



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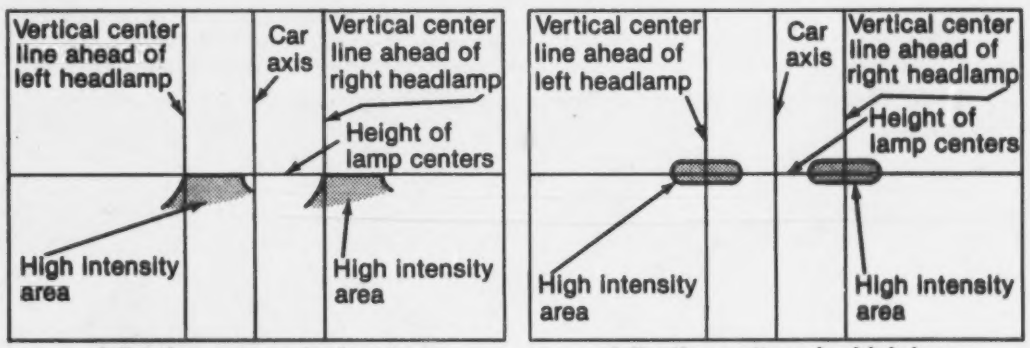
The vehicle must generally be standing on a level surface for the aiming process. The vehicle manufacturer will also specify how the vehicle should be checked, for example, the procedure may have to be done with a full fuel tank and a person in the driver's and front passenger's seats. The manufacturer's service manual will also illustrate how the headlight patterns should appear on the screen when properly adjusted as shown in Figure 4.

FIGURE 4


Vertical center line ahead of left headlamp
Car axis
Vertical center line ahead of right headlamp
Height of lamp centers
High intensity area
High intensity area
Adjusting pattern for low beam
Vertical center line ahead of left headlamp
Car axis
Vertical center line ahead of right headlamp
Height of lamp centers
High intensity area
High intensity area
Adjusting pattern for high beam

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Several fasteners are involved in headlight aiming. In most designs, the headlight is held in a spring-loaded frame, and adjustments are made with adjusting screws. In some cases, trim around the headlights may have to be removed, involving additional fasteners. This job sheet will give you practice working with different types of fasteners while learning the procedures used to aim headlights.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped and to manufacturer's instructions for mechanical or optical aimers.

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PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 1

Inspect and replace air filter

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed fasteners correctly using proper tools.	_____	_____
3. Inspected filter thoroughly.	_____	_____
4. Used reference materials to determine if filter could be cleaned or if filter should be replaced.	_____	_____
5. Installed air filter correctly.	_____	_____
6. Installed fasteners correctly using proper tools.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 2

Replace PCV valve

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Removed fasteners correctly using proper tools.	_____	_____
3. Performed inspection correctly.	_____	_____
4. Replaced PCV valve following procedure outlined in vehicle manufacturer's service manual.	_____	_____
5. Installed fasteners correctly using proper tools.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

973

PRACTICAL TEST	REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 3

Replace fuel filter

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Handled fuel lines properly.	_____	_____
3. Removed fasteners correctly using proper tools.	_____	_____
4. Observed safety rules relating to fuel.	_____	_____
5. Replaced fuel filter following procedure outlined in vehicle manufacturer's service manual.	_____	_____
6. Used approved hose, clamps, and lines.	_____	_____
7. Installed fasteners correctly using proper tools.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

975

PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 4

Remove and reinstall tire-and-wheel assemblies

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Removed fasteners correctly using proper tools.	____	____
3. Removed tire-and-wheel assembly following outlined procedure.	____	____
4. Reinstalled tire-and-wheel assembly following outlined procedure.	____	____
5. Seated wheel on hub properly.	____	____
6. Installed fasteners correctly using proper tools.	____	____
7. Tightened fasteners in sequence and to torque recommended by vehicle manufacturer.	____	____
8. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

976

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

977

PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 5

Remove and Install Hoses

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Observed safety rules relating to substances carried by hoses	_____	_____
3. Removed hose(s) following procedure outlined in vehicle manufacturer's service manual.	_____	_____
4. Removed fasteners correctly using proper tools.	_____	_____
5. Selected correct replacement hose.	_____	_____
6. Installed hose(s) following procedure outlined in vehicle manufacturer's service manual.	_____	_____
7. Installed fasteners correctly using proper tools.	_____	_____
8. Checked connections with and without system operating.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

978

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 6

Inspect and replace shock absorbers

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Tested shock absorbers following outlined procedure.	____	____
3. Inspected shock absorbers following outlined procedure.	____	____
4. Correctly determined whether shock absorbers could be serviced or should be replaced.	____	____
5. Removed shock absorber(s) following procedure outlined in vehicle manufacturer's service manual.	____	____
6. Removed fasteners correctly using proper tools.	____	____
7. Selected correct replacement shock absorber(s).	____	____
8. Installed shock absorber(s) following procedure outlined in vehicle manufacturer's service manual and according to shock absorber manufacturer's instructions.	____	____
9. Installed fasteners correctly using proper tools.	____	____
10. Cleaned work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

REMOVE AND INSTALL COMMON FASTENERS

JOB SHEET 7

Aim headlights

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure.	_____	_____
3. Aimed headlights using mechanical or optical aimers following manufacturer's instructions.	_____	_____
4. Aimed headlights using screen following procedure outlined in vehicle manufacturer's service manual.	_____	_____
5. Used fasteners and tools correctly.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

982

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

WRITTEN TEST

REMOVE AND INSTALL COMMON FASTENERS

Name _____ Score _____

OBJECTIVE 1

Choose the definition that best defines each term. Write the correct numbers in the blanks.

_____a. **Fastener**

1. Device or substance used to hold parts together
2. Throttle control
3. Tool used to remove or install holding devices
4. Automotive part designed to restrict movement of components and assemblies

_____b. **Threaded**

1. Having a grooved or shaped surface for increased traction, such as on a tire
2. Inserted through a small opening
3. Having a raised, spiral ridge designed to match a similar ridge in another part to form a secure hold
4. Having bendable fingers that can be wrapped around joined parts to increase holding power

_____c. **Filter**

1. Device used to increase airflow around the engine for improved cooling
2. Device used to remove unwanted materials from a substance that moves through it
3. Device with a wide opening at one end and a narrow opening at the other end used to help pour substances from their containers into other containers
4. Device used with fasteners to improve hold

_____d. **PCV valve**

1. Device used to control the flow of lubricant to the pumping velocity chamber
2. One of several automotive devices used to prevent harmful substances produced during engine operation from entering the air
3. Valve created from the use of pressurized polychloride vinyl plastics
4. Device used to join tubing and hoses

_____e. **Hose**

1. Assembly or chamber used to protect or contain components
2. Device used to cover threaded fasteners to prevent damage to the threads
3. Tubular part of the exhaust system used to direct exhaust gases from the exhaust manifold to the rear of the vehicle
4. Hollow, generally rubber device used to direct substances from one place to another in automotive systems

_____f. **Shock absorber**

1. Part of the suspension system on many vehicles; used to reduce the amount of vibration caused by traveling over uneven surfaces
2. Type of bumper system used to reduce the effects of collisions
3. Steering column design in which the steering column collapses in the event of a crash to prevent injury to the driver
4. Tool used to install fasteners under high pressure without damaging them

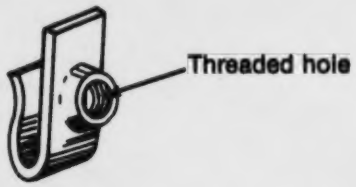
_____g. **Tapped hole**

1. Opening in cooling system where coolant can be added
2. Opening in which raised ridges trap unwanted materials from a substance that moves through it
3. Fastener with external threads
4. Hole in which threads have been cut

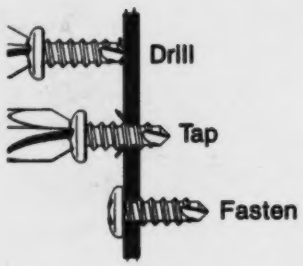
985

OBJECTIVE 2

Name the methods for holding threaded fasteners illustrated below and on the next page. Write the names of the methods in the spaces provided.

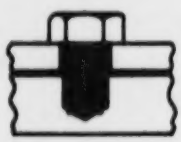


a. _____

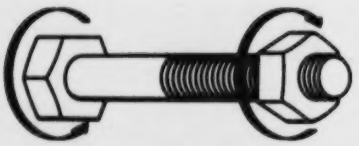


Reprinted with permission of McGraw-Hill Book Company, Gregg Division, *Automotive Mechanics*, 9th ed., by William H. Crouse and Donald L. Anglin, 1985.

b. _____



c. _____



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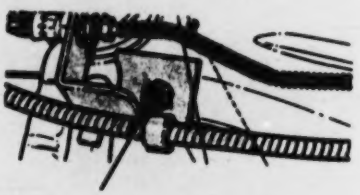
d. _____



Adapted with permission of Chrysler Corporation.

e. _____

OBJECTIVE 3

Identify threaded fasteners by their characteristics. Study the descriptions and illustrations below. Answer the questions with the situations by writing the correct answers in the blanks or by writing an "X" in the blanks before the correct answers.

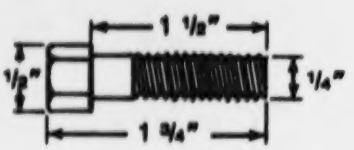
a. Which of the washers shown below is not a locking washer?

_____ Washer A _____ Washer B _____ Washer C

b. What are the correct length and diameter of the cap screw illustrated below?

Length = _____

Diameter = _____



987

c. Which of the two bolts illustrated below has the greater tensile strength?

_____ Bolt A _____ Bolt B

d. Which of the fasteners illustrated below are metric fasteners?

_____ Fastener A _____ Fastener B _____ Fastener C

e. Which of the fasteners illustrated below has normal clockwise threading?

_____ Fastener A _____ Fastener B _____ Fastener C

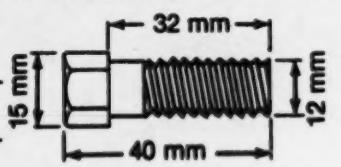
f. Of *coarse*, *fine*, and *extra fine* pitches, which has the fewest threads per inch?

_____

g. What are the length and diameter of the fastener shown below?

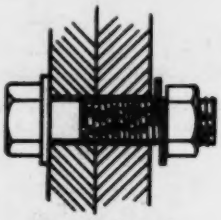
Length = _____

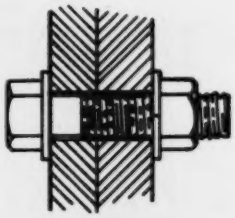
Diameter = _____



988

h. Which of the two illustrations below shows a correct installation of the fasteners?





_____ Illustration A _____ Illustration B

NOTE: Use Table A below to answer questions *i* and *j* for this objective.

i. You need a screw two inches long with a diameter of one-eighth inch and fine threads. Complete the description of the required screw below.

____-____ UN ____-1A x ____

j. You need a second bolt like the one shown below. Complete the description of the required bolt.

____-____ UN ____-2A x ____

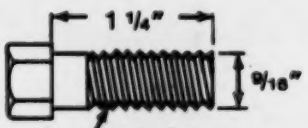


TABLE A: Common customary thread and tap drill size chart

National fine					National course				
Sizes	Threads per inch	Outside diameter at screw	Tap drill sizes	Decimal equivalent of drill	Sizes	Threads per inch	Outside diameter at screw	Tap drill sizes	Decimal equivalent of drill
0	80	.060	3/64	0.0469	1	64	.073	53	0.0595
1	72	.073	53	0.0595	2	56	.086	50	0.0700
2	64	.086	50	0.0700	3	48	.099	47	0.0785
3	56	.099	45	0.0820	4	40	.112	43	0.0890
4	48	.112	42	0.0935	5	40	.125	38	0.1015
5	44	.125	37	0.1040	6	32	.138	36	0.1065
6	40	.138	33	0.1130	8	32	.164	29	0.1360
8	36	.164	29	0.1360	10	24	.190	25	0.1495
10	32	.190	21	0.1590	12	24	.216	16	0.1770
12	28	.216	14	0.1820	1/4	20	.250	7	0.2010
1/4	28	.250	3	0.2130	5/16	18	.3125	F	0.2570
5/16	24	.3125	I	0.2720	3/8	16	.375	5/16	0.3125
3/8	24	.375	Q	0.3320	7/16	14	.4375	U	0.3680
7/16	20	.4375	25/64	0.3906	1/2	13	.500	27/64	0.4219
1/2	20	.500	29/64	0.4531	9/16	12	.5625	31/64	0.4843
9/16	18	.5625	0.5062	0.5062	5/8	11	.625	17/32	0.5312
5/8	18	.625	0.5687	0.5687	3/4	10	.750	21/32	0.6562
3/4	16	.750	11/16	0.6875	7/8	9	.875	49/64	0.7656
7/8	14	.875	0.8020	0.8020	1	8	1.000	7/8	0.875
1	14	1.000	0.9274	0.9274	1 1/8	7	1.125	63/64	0.9843
1 1/8	12	1.125	1 3/64	1.0468	1 1/4	7	1.250	1 7/64	1.1093
1 1/4	12	1.250	1 11/64	1.1718					

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OBJECTIVE 4

Select correct threaded fasteners for specific applications. Read the situations below and answer the questions with the situations by writing the correct answers in the blanks or writing an "X" in the blanks before the correct answers.

a. The nut for the air filter housing cover on a 1966 Plymouth Barracuda has been lost. The cover slips over a threaded stud. What type of nut would you use so that easy access to the air filter would be possible?

_____

b. The fastener at the right must be replaced due to damaged threads. Which of the fasteners below would be a suitable substitute?

_____ Fastener A

_____ Fastener B

_____ Fastener C

_____ Fastener D

c. You must replace a broken stud. The end of the broken stud is shown at the right. Which of the following studs could be used to replace the broken stud?

_____ Stud A

_____ Stud B

_____ Stud C

d. You must install an alarm system on a vehicle. Part of the system is to be mounted to the fender wall under the hood. What type of screws should be used?

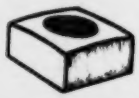
_____

930

e. Which of the two fasteners shown below is used primarily for light, decorative installations?

_____ Fastener A _____ Fastener B

f. Which of the nuts below are self-locking?



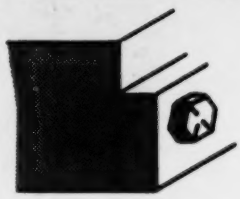
_____ Fastener A _____ Fastener B

_____ Fastener C _____ Fastener D

OBJECTIVE 5

Select correct tools to use in removing and installing threaded fasteners. Read the situations described below, and write an "X" in the blanks before the correct answers or write the correct answers in the blanks.

a. You must remove the cap screw shown at the right. Which tool illustrated below would be best suited for removing the cap screw?



_____ Tool A _____ Tool B

_____ Tool C _____ Tool D

991

b. You have to install the screw shown at the right. Which tool below would be best suited for the job?

_____ Tool A

_____ Tool B

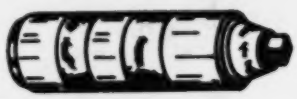
_____ Tool C

_____ Tool D

c. The wrench shown at the right is designed primarily to remove what type of fastener?

_____

d. A nut has rusted in place on a bolt. Which of the tools shown below is best suited for removing the nut?



_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

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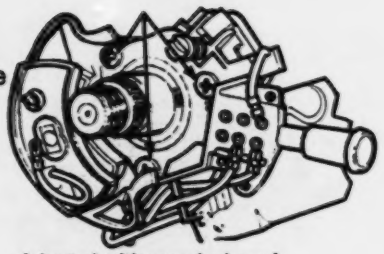
e. You must remove the Phillips screws shown in the installation illustrated at the right. Which of the tools shown below would be best suited for removing the screws?



Adapted with permission of Chrysler Corporation.

_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

OBJECTIVE 6

Apply guidelines for the use of threaded fasteners. Read the situations below and on the next page. Answer the questions with the situations by writing the correct answers in the blanks or by writing an "X" in the blanks before the correct answers.

a. What two things should be done to a threaded fastener before it is reused?

_____

_____

b. Which of the two illustrations below shows the correct way to hold a wrench while tightening a nut?

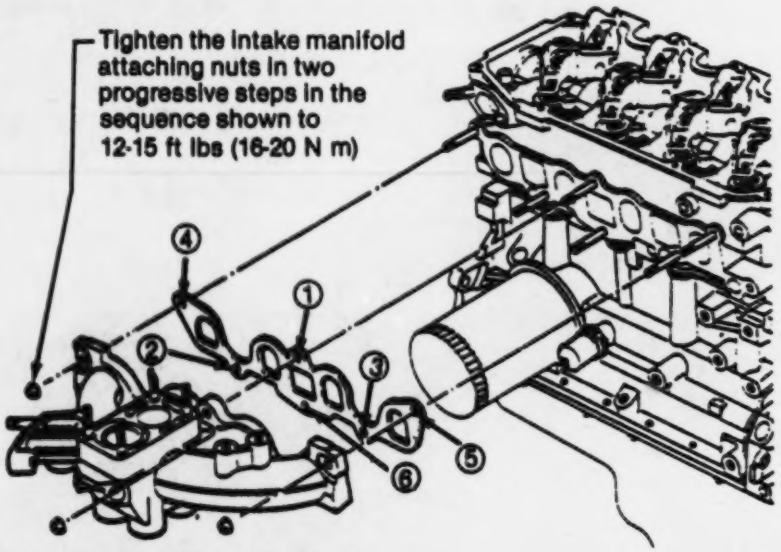
_____ Illustration A

_____ Illustration B

c. The correct way to begin installation of a threaded fastener to ensure that the threads have properly mated is to

_____

NOTE: Use the illustration below to answer question *d* and *e*.



Used with permission of Ford Motor Company.

d. The correct sequence for torquing the bolts requires the service specialist to begin in the middle, at the left end, or at the right end?

_____

e. The torque requirements for the fasteners holding the manifold are

_____ foot-pounds.

OBJECTIVE 7

Select correct nonthreaded fasteners for specific applications. Read the situations below and answer the questions with the situations. Write the correct answers in the blanks or write an "X" in the blanks before the correct answer.

a. You are installing a new fuel filter and are connecting the hoses to the ends of the filter. Which nonthreaded fastener shown below would be best suited to connect the hoses to the filter?

_____ Clamp A _____ Clamp B _____ Clamp C

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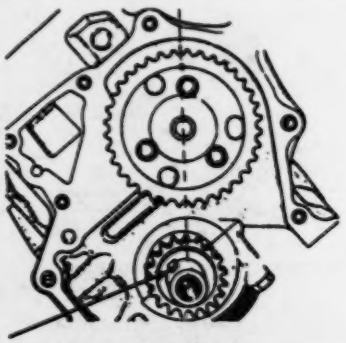
b. One type of nonthreaded fastener is used to prevent other parts from moving out of position. It fits into grooves on either the outside or inside of a shaft. What is the name of this type of nonthreaded fastener?

_____

c. The illustration below shows a nonthreaded fastener used to hold a shaft in place. What is this type of nonthreaded fastener called?

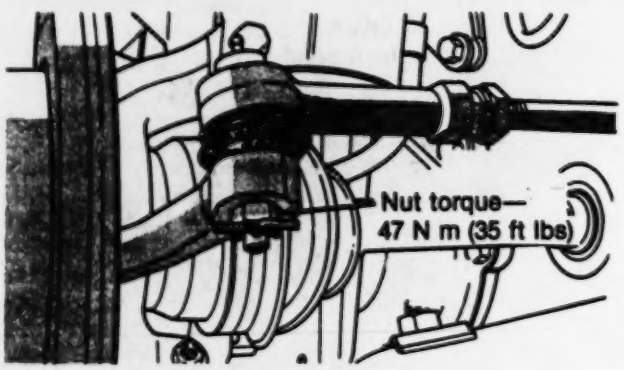
_____



From *Chilton's Auto Repair Manual 1985*, Chilton Book Company, Radnor, PA.

d. The illustration below shows the installation of a tie rod end into the steering arm. The installation is completed by torquing the nut to specifications and then installing a nonthreaded fastener to secure the nut. What is the name of this nonthreaded fastener?

_____



Used with permission of Chrysler Corporation.

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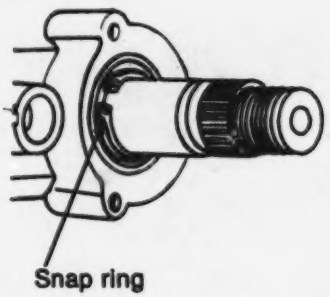
e. In many modern vehicles, a nonthreaded fastener is used to attach the rearview mirror to the windshield. This same fastener is often used to attach body side molding to newer-model vehicles. What is the name of this nonthreaded fastener?

_____

OBJECTIVE 8

Select correct tools to use with nonthreaded fasteners. Read the following situations and answer the questions with the situations. Write an "X" in the blanks before the correct answers.

a. Which of the tools illustrated below is best suited to remove the snap ring indicated with the arrow in the installation shown at the right?



Adapted with permission of Chrysler Corporation.

_____ Tool A

_____ Tool B

_____ Tool C

_____ Tool D

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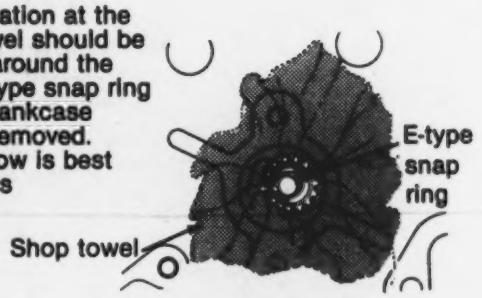
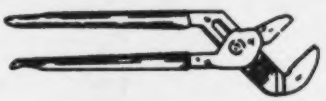
b. As shown in the illustration at the right, a clean shop towel should be inserted in the cavity around the gear to prevent the E-type snap ring from falling into the crankcase when this fastener is removed. Which of the tools below is best suited for removing this nonthreaded fastener?



Adapted with permission of Chrysler Corporation.

____ Tool A

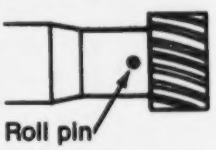
____ Tool B



____ Tool C

____ Tool D

c. To remove the roll pin shown in the installation at the right, which tool illustrated below should you use?



____ Tool A

____ Tool B

____ Tool C

____ Tool D

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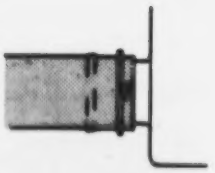
d. Which of the tools illustrated below is best suited for installing and removing the hose clamp shown at the right?



____ Tool A

____ Tool B

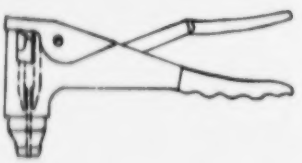
____ Tool C

____ Tool D

e. You need to install the nonthreaded fastener shown at the right. Holes have been drilled at the proper locations. Which of the tools below should you now use to install this fastener?

____ Tool A

____ Tool B



____ Tool C

____ Tool D

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

WRITTEN TEST ANSWERS	REMOVE AND INSTALL COMMON FASTENERS

OBJECTIVE 1

a. 1
b. 3
c. 2
d. 2
e. 4
f. 1
g. 4

OBJECTIVE 2

a. With a threaded clip
b. With a self-tapped hole
c. With a hole tapped into a solid part
d. With other fasteners
e. With hole tapped into a cast nut

OBJECTIVE 3

a. Washer C
b. Length = 1 1/2 inches
   Diameter = 1/4 inch
c. Bolt B
d. Fastener A, Fastener B
e. Fastener A
f. Coarse
g. Length = 32 mm
   Diameter = 12 mm
h. Illustration B
i. 5 - 44 UNF - 1A x 2
j. 9/16 - 12 UNC - 2A x 1 1/4

OBJECTIVE 4

a. Wing nut
b. Fastener D
c. Stud A, Stud C
d. Metal (self-tapping)
e. Fastener B
f. Fastener A, Fastener D

OBJECTIVE 5

a. Tool B
b. Tool A
c. Tubing couples
d. Tool C
e. Tool B

OBJECTIVE 6

a. It should be cleaned and inspected
b. Illustration A
c. Hand-start the fastener
d. In the middle
e. 12 to 15

OBJECTIVE 7

a. Clamp B
b. Snap ring
c. Key
d. Cotter pin
e. Adhesive

OBJECTIVE 8

a. Tool C
b. Tool B
c. Tool B
d. Tool A
e. Tool D

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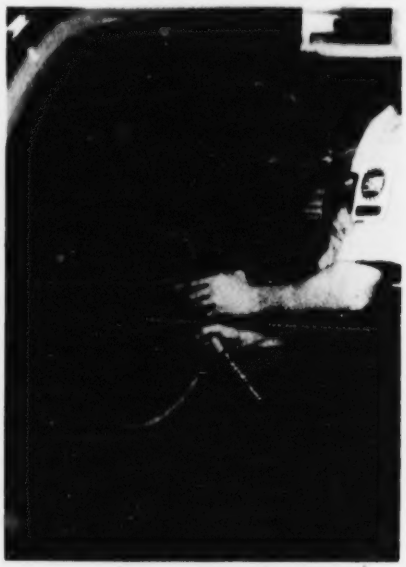
OBJECTIVE SHEET

UNIT B-3 USE COMMON HAND AND POWER TOOLS

INTRODUCTION



Automotive service requires the use of a great variety of tools and equipment in order to properly maintain vehicle systems. Some tools operate off power, such as electricity or compressed air. Both power and hand tools come in a variety of designs for specific applications. A service specialist must have a good collection of quality hand and power tools, and know how to use them correctly.

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and use common hand and power tools. The student will demonstrate these competencies by completing job sheets and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit B-2, "Remove and Install Common Fasteners."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated witn common hand and power tools by choosing the correct definition from a list of three choices.
2. Recognize types of cutting tools by matching the name of each to an illustration.
3. Recall types of holding tools by naming the illustrated tools.
4. Recall common power tools by naming the illustrated tools.
5. Recall uses of tire and wheel tools by writing the use of each tool.

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6. Remove damaged threaded fasteners. (Job Sheet 1)
7. Tap a hole. (Job Sheet 2)
8. Remove and install flared tubing. (Job Sheet 3)
9. Shape a chisel on a bench grinder. (Job Sheet 4)
10. Remove and replace exhaust system components. (Job Sheet 5)
11. Remove, inspect, repair, and replace a tire on a wheel. (Job Sheet 6)

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SUGGESTED ACTIVITIES	USE COMMON HAND AND POWER TOOLS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstrations of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit.

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare classroom and shop. Display posters, charts, safety signs, etc., that emphasize hand and power tools and their uses.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss information to the unit (see "Objective Sheet"). Explain to students that automotive service specialists use hand and power tools almost daily and that it is important for the students to be familiar with these tools and understand their uses.

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- List on the chalkboard local businesses that provide automotive service, and discuss the various tools that are used, explaining why each tool is necessary.

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive service specialist. Also relate the objectives to your introduction and to materials previously covered.

Objective 1 Recognize definitions of terms associated with common hand and power tools

- Point to examples that illustrate terms in the shop and make examples available in the classroom.

Objective 2 Recognize types of cutting tools

- Show students each of the common cutting tools. Explain their use, pointing out the features of each tool.

- Have students read Student Supplement 1, "Guidelines for Using Cutting Tools," and discuss the guidelines for each cutting tool.

- Ask students if they can think of automotive service situations in which cutting tools are used.

- Discuss the box material, "Files and Their Shapes," and stress the importance of using the correct file for the job being done. Also discuss the box material, "Taps and Dies," and explain to students how and when these tools are used.

- Demonstrate the proper use of each of the common cutting tools.

Objective 3 Recall types of holding tools

- Show students examples of each of the holding tools, and explain various ways the tools are used.

  EXAMPLES: Show how a pry bar is used to apply pressure to hold parts in the correct position until they can be fastened securely.

- Have students read Student Supplement 2, "Guidelines for Using Holding Tools," and discuss the guidelines in class.

- Discuss the need for using holding tools. Have students list different automotive service situations requiring the use of holding tools.

Objective 4 Recall common power tools

- Show students examples of the common power tools. Discuss the uses of power tools, and where possible, demonstrate their uses.
- Have students read Student Supplement 3, "Guidelines for Using Power Tools," and discuss in class.

Objective 5 Recall uses of tire and wheel tools

- Show examples of the different tire and wheel tools, and demonstrate the use of each.
- Discuss jobs requiring the use of these tools, and relate them to local places of employment.
- Visit companies that use a variety of types of tire tools.

Objective 6 Remove damaged threaded fasteners

- Tell students of instances when it is necessary to remove damaged threaded fasteners.
- Discuss the importance of considering such factors as location of fastener when deciding which removal procedure should be used. Include in your discussion instances where heat cannot be used, and review all pertinent safety rules and precautions dealing with combustible materials.
- Also discuss instances where using the incorrect removal procedure could damage not only the fastener but also the part(s) the fastener secures or parts nearby.
- Review with students applicable safety rules and precautions, emphasizing the importance of wearing eye protection when performing this or any procedure.
- Explain the purpose of penetrating oil, show students the forms in which it is available, and demonstrate the proper application for each form of penetrating oil.
- Make sure that students know how to correctly set up, light and adjust, and use a heating torch. Assist students as necessary when they practice removing damaged threaded fasteners using heat.
- Review with students the guidelines given in Student Supplements 1 through 3 and the guidelines given in the job-sheet introduction.
- Demonstrate the proper use of the tools used and the different removal procedures in Job Sheet 1, "Remove Damaged Threaded Fasteners." Have students practice Job Sheet 1 with a variety of damaged fasteners, including frozen fasteners and broken bolts, studs, and screws, until they are ready to take the practical test.

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Objective 7 Tap a hole

- Explain what a tap does, and give instances when tapping a hole is necessary.
- Discuss the appropriate uses of bottoming taps and tapered taps.
- Show students a thread gauge, and demonstrate how to measure threads and how to select a tap to match.
- Display a drill and tap size chart, and explain to students how to use the chart to determine the correct size of drill bit to use.
- Review with students the guidelines for using cutting, holding, and power tools given in Student Supplements 1 through 3. Also review applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 2, "Tap a Hole." Have students practice Job Sheet 2 until they are ready to take the practical test.

Objective 8 Remove and install flared tubing

- Show students a flaring tool, and explain its use.
- Display a variety of tools used to bend tubing, and demonstrate the correct use of each of these tools.
- Explain to students how to determine the type and size of fittings to use with tubing.
- Review with students the guidelines given in Student Supplements 1 through 3. Also review applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate the cutting, flaring, and bending procedures in Job Sheet 3, "Remove and Install Flared Tubing." Have students practice Job Sheet 3 until they are ready to take the practical test.

Objective 9 Shape a chisel on a bench grinder

- Have students review Student Supplement 3, "Guidelines for Using Power Tools," and discuss in class. Also discuss safety rules that students must follow when working with power tools, and review the guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 4, "Shape a Chisel on a Bench Grinder." Have students practice Job Sheet 4 until they are ready to take the practical test.

Objective 10 Remove and replace exhaust system components

- Discuss with students the different types of fasteners used to secure exhaust system components and the types of tools needed to remove and install these fasteners.
- Explain to students how to inspect the various components and how to determine when it is necessary to replace a component.
- Show students the various gaskets used, and explain when it is necessary to replace the gaskets.
- Discuss applicable guidelines from Student Supplements 1 through 3. Review applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 5, "Remove and Replace Exhaust System Components." Have students practice Job Sheet 5 until they are ready to take the practical test.

Objective 11 Remove, inspect, repair, and replace a tire on a wheel

- Explain the basic features of a tire machine using the machine(s) in your shop or illustrations of various tire machines.
- Review with students Student Supplements 2 and 3, "Guidelines for Using Holding Tools" and "Guidelines for Using Power Tools." Also review applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 6, "Remove, Inspect, Repair, and Replace a Tire on a Wheel." Have students practice Job Sheet 6 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, "Report on Specialty Tools." The purpose of the activity is to give students an awareness of the many different specialty tools, instances of when they are used, and information about these tools provided in the service manuals. Keep this in mind when discussing the assignment.
- Have students complete Activity Sheet 1.

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EVALUATION

- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston, Massachusetts: Breton Publishers, A Division of Wadsworth, Inc., 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill Book Company, 1985.
- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service*. Cincinnati, Ohio: South-Western Publishing Co., 1986.
- *Fundamentals of Service: Fasteners*, 3rd ed. Moline, Illinois: Deere & Company, 1987.
- Henderson, Chuck, and Ivan Armstrong. *Auto Mechanics I*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1976.
- Hendrix, Laborn J. "Bud." *Fundamentals of Carpentry*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center and The Associated General Contractors of America, 1985.
- *Introduction to Automotive Mechanics, Unit 1: Hand Tools, Automotive Fasteners, Shop Equipment and Supplies*, rev. ed. Tallahassee, Florida: Florida Department of Education, 1982.
- *Introduction to Automotive Mechanics, Unit 3: Tire Service*, rev. ed. Tallahassee, Florida: Florida Department of Education, 1982.
- Litton, Bill, and James Sharpton. *Introduction to Auto Body*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1985.
- Patton, Bob, and Keith Harp. *Vocational Agriculture I*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1984.

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PRETEST ANSWERS

USE COMMON HAND AND POWER TOOLS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	6, 26, 32
2	2, 7, 8, 17
3	3, 10, 27
4	4, 14, 29
5	20, 23, 24
6	9, 15, 19
7	5, 13, 21, 25
8	18, 22, 28
9	11, 30
10	1, 12, 16
11	31, 33

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ANSWER KEY

1. c
2. b
3. c
4. d
5. b
6. b
7. a
8. c
9. a
10. b
11. a
12. b
13. d
14. a
15. d
16. d
17. b
18. a
19. d
20. d
21. c
22. c
23. c
24. b
25. a
26. a
27. d
28. c
29. a
30. d
31. a
32. d
33. a

10:0

PRETEST

USE COMMON HAND AND POWER TOOLS

Name _____ Score _____

DIRECTIONS

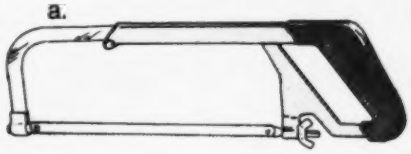
Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which of the following is **not** a task normally performed on exhaust systems?

   a. Replace damaged or defective parts
   b. Tighten loose connections
   c. Bore out clogged system components
   d. Align parts to ensure that they do not contact other parts

2. Which of the following tools is a tubing cutter?

a.



b.

c.

d.

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3. What is the name of the tool illustrated below?

a. Hacksaw
b. Screw extractor
c. C-Clamp
d. Vise

4. What type of tool is shown below?

a. Cutting tool
b. Holding tool
c. Specialty tool
d. Power tool

5. Which of the following statements concerning tapping a hole is correct?

a. A tapered tap should be used if the hole to be tapped does not go completely through the metal
b. A bottoming tap should be used if the hole to be tapped does not go completely through the metal
c. A bottoming tap should be used if the hole to be tapped goes completely through the metal
d. Both a and c

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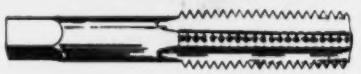
6. Which of the following best defines *pneumatic*?

   a. Powered by electricity
   b. Powered by compressed air
   c. Powered by movement and force of a liquid
   d. None of the above

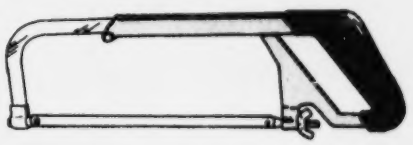
7. The cutting tool shown below is a



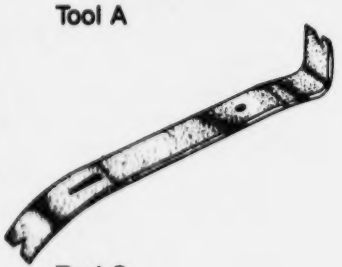
   a. Tap
   b. Die
   c. Hand reamer
   d. None of the above

8. Which of the following tools are cutting tools?

Tool A



Tool B



Tool C

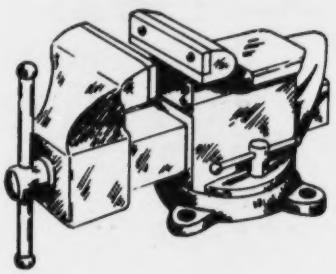
Tool D

   a. Tools A, B, and C
   b. Tools A, C, and D
   c. Tools A, B, and D
   d. All are cutting tools

9. Which of the following statements concerning the removal of frozen nuts or bolts is correct?

   a. They may be removed by using penetrating oil
   b. Penetrating oil or heat can be used to remove any frozen nuts or bolts on a vehicle
   c. Heat may be used in any areas where there is no wiring or plastic components present
   d. Both a and c

10. What type of tool is illustrated below?



   a. Cutting tool
   b. Holding tool
   c. Power tool
   d. None of the above

11. Which of the statements below is **not** a guideline that should be followed when shaping a chisel on a bench grinder?

   a. The edge of the chisel should be ground to an included angle of 90°
   b. Never use a grinder with a cracked or damaged wheel
   c. Alert others in the area if chisel head is mushroomed
   d. Always wear eye protection

12. The two *most* dangerous defects in an exhaust system are

   a. Excessive vibration and leakage of toxic gases
   b. Clogged systems and leakage of toxic gases
   c. Overheating and excessive vibration
   d. Clogged systems and overheating

13. When tapping a hole, it is important that

    a. The tap be square to the part being tapped
    b. The tap be backed out every few turns to break chips
    c. The hole be drilled only with a drill press
    d. Both a and b

14. The tool illustrated below is

    a. An air nozzle
    b. A drill motor
    c. A trouble light
    d. None of the above

15. Which of the following factors must be considered when deciding which method to use to remove damaged threaded fasteners?

    a. Location of fastener
    b. Tools available
    c. Damage that will be done to the fastener and the parts
    d. All of the above

16. An exhaust manifold may be reused if no more than _____ of the openings are restricted.

    a. One
    b. One-fourth
    c. One-half
    d. None; all openings must be unrestricted

1015

17. The tool shown below is called a

a. Punch
b. Chisel
c. Impact driver
d. Nut splitter

18. Specialist A says that a ferrule is used to secure unions onto tubing. Specialist B says that the only way to secure tubing unions is to flare the ends of the tubing.

Who is correct?

a. Specialist A
b. Specialist B
c. Both A and B
d. Neither A nor B

19. Damaged threaded fasteners may be removed by using which of the following methods?

a. Using a screw extractor
b. Using a jam nut
c. Using a punch
d. All of the above

20. A bead lifter is used

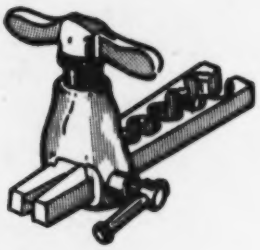
a. To remove tire from wheel and to install tire on wheel
b. To remove lug nuts from lug bolts when removing wheel
c. To repair tire punctures
d. With tire machine to separate the tire from the wheel

21. A *tap* is used to

a. Remove damaged threaded fasteners
b. Cut external threads, such as for bolts or screws
c. Thread a hole
d. Lightly strike a frozen fastener in order to loosen the fastener without causing further damage

1016

22. The tool shown below is called a



a. Tubing cutter
b. Pipe press
c. Flaring tool
d. Hand reamer

23. A tire machine is used to

a. Check tires for defects
b. Hold the tire after the rim has been removed
c. Remove tire from wheel and to install tire on wheel
d. Remove and install valve stems in tires

24. Which of the following are used to repair tire punctures?

a. Valve stem remover
b. Patching tools
c. Tire machine
d. All of the above

25. Which of the following statements about tapping a hole is **not** correct?

a. It is not necessary to drill the hole before using the tap; the tap drills and cuts threads at the same time
b. A critical step in preparation is determining the required thread gauge
c. A hole that has been enlarged may be rethreaded
d. Cutting oil should be used if tapping a hole in hard metal

1017

26. Which of the following is the best definition of *tire bead*?

a. Inner portion of tire shaped to fit wheel rim
b. Material used to make radial tires
c. Outer surface of tire shaped in various patterns for different types of road conditions
d. Both b and c

27. Which of the following tools are holding tools?

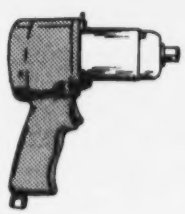
a. C-clamp
b. Pry bar
c. Neither a nor b
d. Both a and b

28. Which of the following conditions does **not** require replacement of the metal tubing and/or connections?

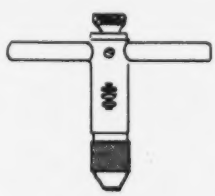
a. Tubing that is slightly kinked with no broken or worn areas
b. Broken tubing
c. Loose connections
d. Tubing that is kinked or clogged

29. Which of the following tools is an impact wrench?

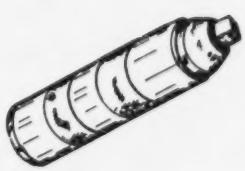
a.



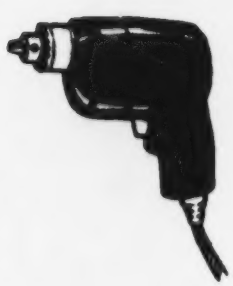
b.



c.



d.



1018

30. The mushroomed head of a chisel

a. Presents a danger in the shop
b. Should be ground to the proper shape
c. Is a result of regular use
d. All of the above

31. Which of the following is **not** a task commonly done on a tire machine?

a. Wheel balancing
b. Removal of tire from wheel
c. Installation of tire on wheel
d. Setting of tire bead with compressed air

32. Which of the following is the best definition of ***penetrating oil***?

a. Fluid used to cool, lubricate, or aid in removal of chips when cutting metal
b. Engine lubricant used with some of the late-model vehicles, especially sport cars
c. Special type of lubricating fluid used in the brake system
d. Lubricant that flows between fastener threads to help in the removal of parts

33. Tire machines are potentially dangerous because of

a. The high pressure of compressed air and force of the mechanisms
b. The high pressure of the hydraulic hoses and the fire danger of hydraulic fluids
c. The danger of electrical shock and force of the mechanisms
d. The high pressure of compressed air and the danger of sparks from rotating parts

INFORMATION SHEET	USE COMMON HAND AND POWER TOOLS

OBJECTIVE 1

Recognize definitions of terms associated with common hand and power tools

Catalytic converter — Exhaust system component which chemically changes harmful exhaust gases into harmless gases

Cutting oil — Fluid used to cool, lubricate, or aid in removal of chips when cutting metal

Gasket — Soft material used to seal areas between nonmoving parts

Hydraulic — Powered by movement and force of a liquid

Penetrating oil — Lubricant that flows between fastener threads to help in the removal of parts

Pneumatic — Powered by compressed air

Saturate — To thoroughly soak or penetrate

Tire bead — Inner portion of tire shaped to fit wheel rim

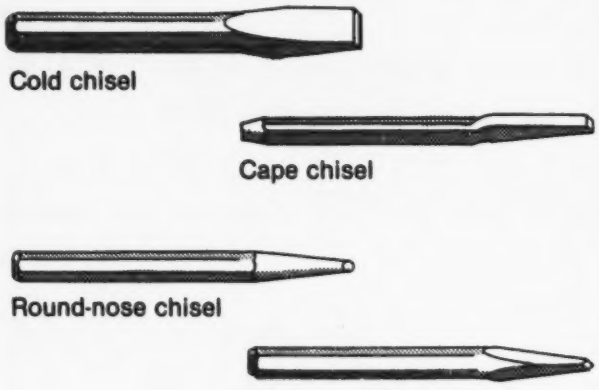
1020

OBJECTIVE 2 | **Recognize types of cutting tools**

- Chisels (Figure 1)

  NOTE: Chisels are used to cut metal, such as cutting off screws or bolts, and to chip flat surfaces. There are different designs of chisels, each having different uses.

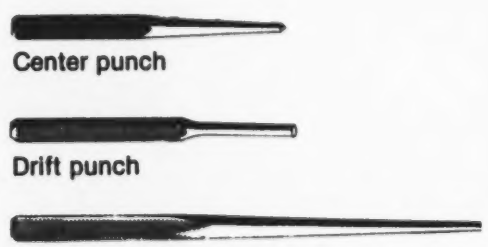
FIGURE 1



- Punches (Figure 2)

  NOTE: Punches are used to mark or punch holes in metal.

FIGURE 2



Chisels, Punches, and Drifts

Chisels, punches, and drifts are all similar in design and use, but they vary slightly and have different purposes. Each is a slender metal rod, pointed at one end and flattened on the other so that it can be hit by a hammer to cut or mark metal. Chisels have four basic point designs. Chisels are used primarily to split metal, such as for breaking a bolt from which the nut cannot be removed.

In order to get a better grip on a chisel and to avoid hitting their hands, service specialists sometimes use chisel holders.

Chisel holder

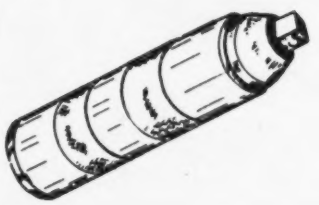
Punches generally have more pointed tips than chisels and are used to mark metal so that a drill can be started. The punch hole keeps the drill bit from moving about over the surface of the material. A drift is similar to a punch except that it has a flat surface at the tapered end. Drifts are used to remove pins and other fasteners from holes. The drift is driven in from one side, forcing the pin out the other side.

1021

- Impact driver (Figure 3)

  NOTE: An impact driver is similar to a chisel but is designed specifically for the removal of damaged fasteners. The cutting edge is driven into the damaged slot in a screw, for example, to provide a secure grip for removing the fastener.

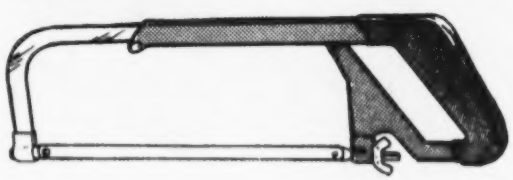
FIGURE 3



- Hacksaw (Figure 4)

  NOTE: Hacksaws are used to saw metal parts to size or shape by hand and to remove damaged fasteners.

FIGURE 4



- Nut-splitter (Figure 5)

  NOTE: Nut-splitters are used to cut through frozen nuts so that they can be freed from bolts or studs.

FIGURE 5

- Tubing cutter (Figure 6)

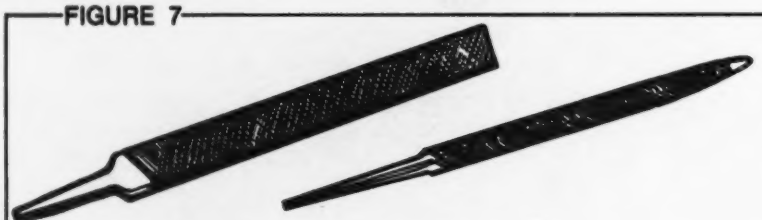
  NOTE: A tubing cutter is used to cut metal tubing without bending or kinking the tubing.

FIGURE 6

- Files (Figure 7)

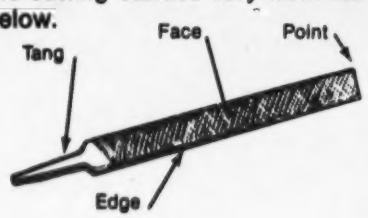
  NOTE: Files are used to smooth, shape, or remove sharp edges or rust from metal.

FIGURE 7

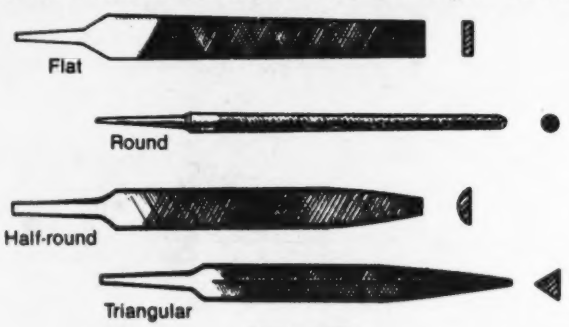


Files and Their Shapes

Files are designed to remove small amounts of metal or to smooth rough metal surfaces or jagged edges. Because these purposes differ and because various types of metals are involved, files are made in a variety of designs. Both the shape of the file and the design of the cutting surface vary from file to file. A few of the more common designs are shown below.



Parts of a file



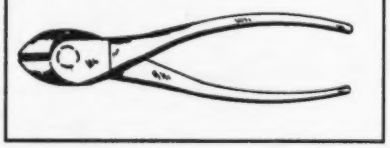
Types of files

1023

- Cutting pliers (Figure 8)

  NOTE: Cutting pliers are used to cut wire and to hold small parts.

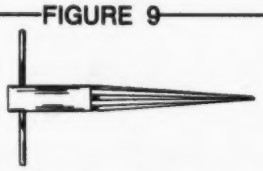
FIGURE 8



- Hand reamer (Figure 9)

  NOTE: Hand reamers smooth or enlarge drilled holes.

FIGURE 9



- Tap and die (Figure 10)

  NOTE: Taps are used to make internal threads, and dies are used to make external threads. A *tap wrench* is used to hold the tap, and a *die stock* is used to hold the die (Figure 11).

FIGURE 10

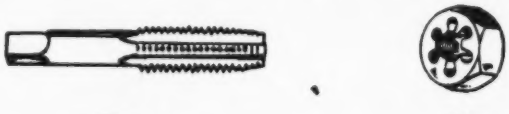
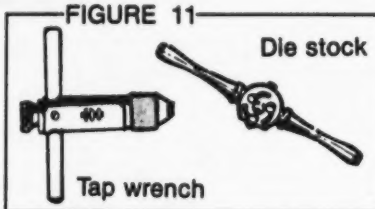


FIGURE 11



Taps and Dies

Taps and dies are used to make threads. Taps are used to make threads inside a hole so that a bolt or stud can be installed. These are called *internal threads*. Dies are used to make threads on the outside of a rod or pipe. These are called *external threads*. A service specialist in the automotive field should be familiar with how to use taps and dies to make threads because the skill can often be used to save parts that would otherwise have to be thrown away. For example, if one of the carburetor mounting holes on an intake manifold has been stripped—that is, the threads have been ruined—it may be possible to tap a new hole and replace the bolt with a larger one. At other times, such repairs will not be possible for the service specialist but may be possible for a trained machinist. Automotive machine shops have the equipment and personnel to resurface and reshape damaged parts, such as reworking valves to specifications, milling warped engine heads and manifolds flat, and tapping holes. The automotive service specialist will want to get to know a good machinist or be prepared to learn those skills and invest a great deal of time and money into having a well-equipped machine shop.

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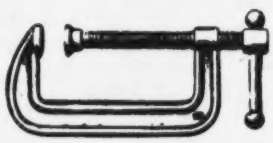
OBJECTIVE 3 | **Recall types of holding tools**

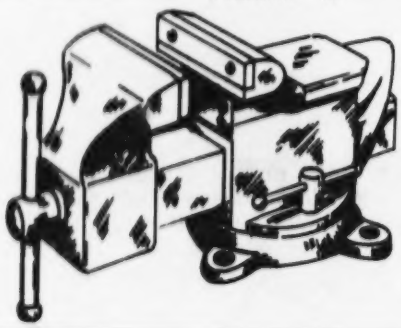
- C-clamp

FIGURE 12



- Vise

FIGURE 13



- Pry bar

FIGURE 14

What Needs to Be Held?

A number of procedures performed by service specialists require that parts be held securely on a temporary basis. For example, parts may need to be held while adhesive is setting or in order to align parts so that fasteners can be inserted more easily. A vise can be used to hold a part securely while it is being drilled or hammered or fitted with another part. C-clamps and vises are also used to press parts out or to press them together, such as pressing universal joints or brake pistons. Pry bars allow the service specialist to hold a part in place by putting pressure against the part with one end of the pry bar while the other end is wedged against a brace. This may be done in order to align parts so that fasteners may be inserted or to put proper tension on belts. The important thing to remember when using holding tools is that parts can be damaged and personal injury can occur if the tools are not used correctly. To understand this more fully, check a service manual and read about setting the tension on the power steering pump belt. Are pry points identified? What kind of damage can occur if the procedure is not performed correctly?

OBJECTIVE 4

Recall common power tools

Pneumatic power tools

- Air compressor (Figure 15)

  NOTE: An air compressor is used to supply pneumatic shop and spray equipment with clean, dry air.

FIGURE 15

- Air nozzle (Figure 16)

  NOTE: Air nozzles are used to direct compressed air for cleaning hard-to-reach areas and air filters.

FIGURE 16

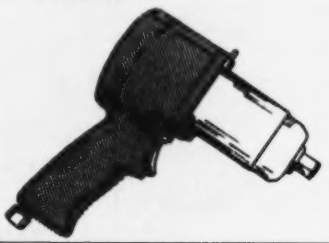
Power

The reason that vehicles are valuable to us is that they provide us with a source of powered transportation. Sure, they can be fun and they can be status symbols, but their basic function is to move people and things from place to place. This requires power. There are several kinds of power, and automotive designs make use of many of them. You will study more about power and work and energy later, but basically, power is the use of energy to do work. Energy takes many forms, such as light, heat, electrical, nuclear, and others. In order to do work, energy must move from one point to another. In vehicles, energy is normally transferred in one of five ways. You are familiar with *electrical* energy, used to power lights, electric window motors, and other accessories. *Chemical* energy from burning fuel powers the engine. Power from the engine is transferred *mechanically* to the wheels through the transmission or transaxle and drive train. Power is also transferred through the use of fluids, in the brake system for example. This is called *hydraulic* power. Energy is also moved about through the use of air pressure, and this is called *pneumatic* power. Many components work off changes in air pressure that result from engine operation. This power is transferred through vacuum lines. Automotive service tools also use various means of power to do work. Many jacks, for example, are hydraulic. Some tools are pneumatic, while others are powered by electricity.

- Impact wrench (Figure 17)

  NOTE: An impact wrench is used to loosen and tighten bolts.

FIGURE 17

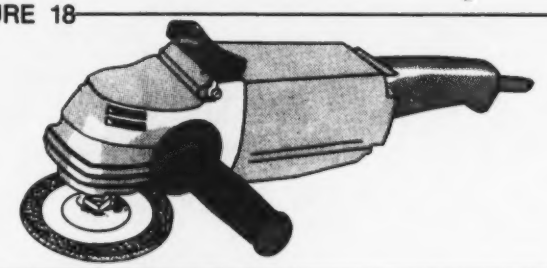


Electric power tools

- Portable grinder (Figure 18)

  NOTE: A portable grinder is used to remove paint, to buff and grind metal, and to grind welds.

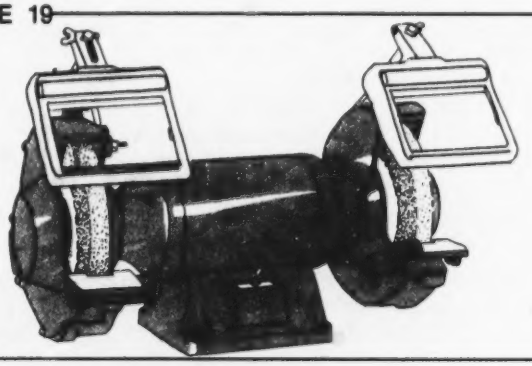
FIGURE 18



- Bench grinder (Figure 19)

  NOTE: A bench grinder is used to dress punches and chisels, to sharpen drill bits, and to grind metal.

FIGURE 19

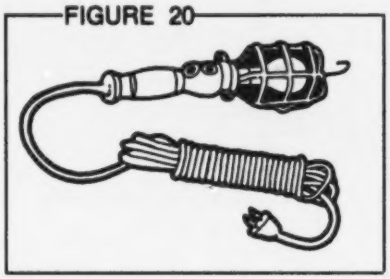


1027

- Trouble light (Figure 20)

  NOTE: Trouble lights provide a portable light source that can be located near work areas.

FIGURE 20

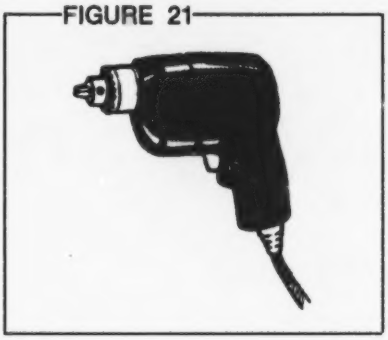


From *Introduction to Automotive Mechanics, Unit 1: Automotive Fasteners, Shop Equipment and Supplies*, rev. ed., © 1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

- Drill motor (Figure 21)

  NOTE: A drill motor is used with drill bits to drill and bore, and it can be used with other attachments such as a wire brush to clean metal.

FIGURE 21



Drill Attachments

You have learned enough about the uses of fasteners and the design of automotive parts and components to know how much turning is required. . .things are screwed in and out, bored, tapped, reamed, extracted, and ground by turning actions. It is no wonder, then, that power should be harnessed to provide torquing energy. One source of this power is the pneumatic or electric drill. Actually, drill bits are just one attachment that can be used with this handy tool. Other attachments allow the service specialist to use the electric drill motor or the pneumatic drill for just about any job that requires turning. For example, screwdriver bits are available for just about any type of screw head. Sockets are also available. You can tap a hole using a drill, though this is usually limited to drill presses. Portable drill motors can be used to grind, polish, or hone surfaces. These are all methods of smoothing surfaces to make them more attractive or less resistant to other parts moving over them.

OBJECTIVE 5

Recall uses of tire and wheel tools

Lug wrench — Used to remove lug nuts from lug bolts when removing wheel (Figure 22)

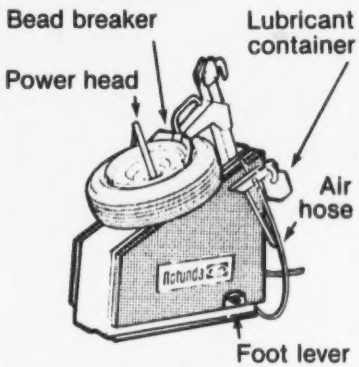
EXAMPLE:

FIGURE 22

Tire machine — Used to remove tire from wheel and to install tire on wheel (Figure 23)

EXAMPLE:

FIGURE 23

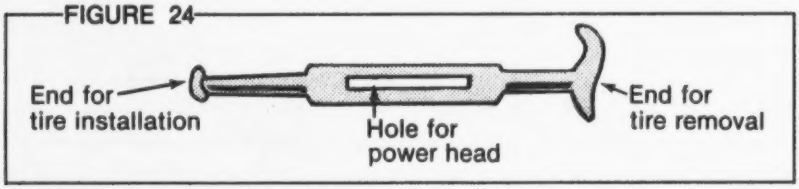


Used with permission of Ford Motor Company.

Bead lifter — Used with tire machine to separate the tire from the wheel (Figure 24)

EXAMPLE:

FIGURE 24



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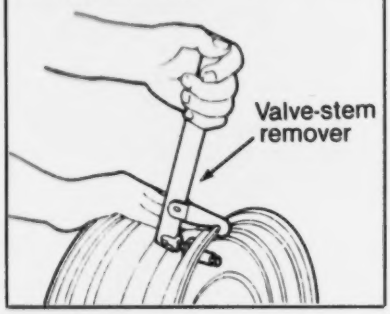
1029

Valve-stem remover — Used to remove and install valve stems in tires (Figure 25)

EXAMPLE:

FIGURE 25

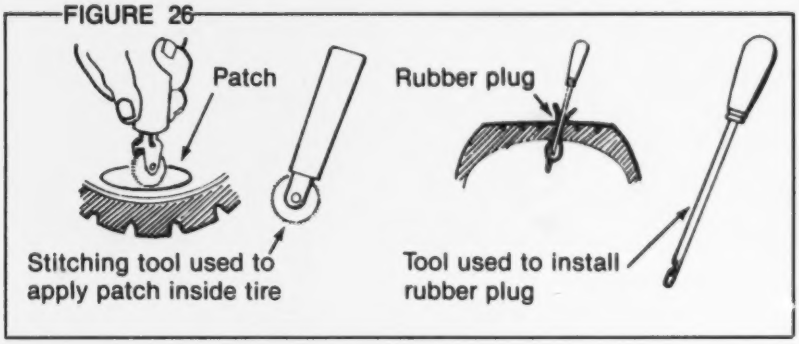


From *Introduction of Automotive Mechanics, Unit 3: Tire Service*, rev. ed., © 1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

Patching tools — Used to repair tire punctures (Figure 26)

EXAMPLE:

FIGURE 26



Wheel Balancing

In order to give the most service, tire-and-wheel assemblies must be balanced. A tire that is out of balance will wobble, leading to a rougher ride, steering problems, and uneven wear. A balanced tire-and-wheel assembly has the entire weight of the assembly evenly distributed around the center of the wheel. Because this does not normally occur during the manufacture of the tire and the manufacture of the wheel, weights must be added to the wheel to make the weight distribution even. In order to tell how much weight is required and where it must be placed in order to balance the wheel, a wheel balancing machine is used. There are three basic types of wheel balancing machines. One uses a bubble level. The tire and wheel are placed on the machine, and the bubble indicates whether part of the assembly is heavier. Another type of off-car balancer spins the tire-and-wheel assembly and indicates vibration due to uneven balance. The third type of balancer spins the tire and wheel while it is still mounted on the vehicle. Vibration is indicated by an electronic or hand-operated device. In this way, the entire wheel assembly including wheel cover, brake disc, and lug fasteners can be balanced.

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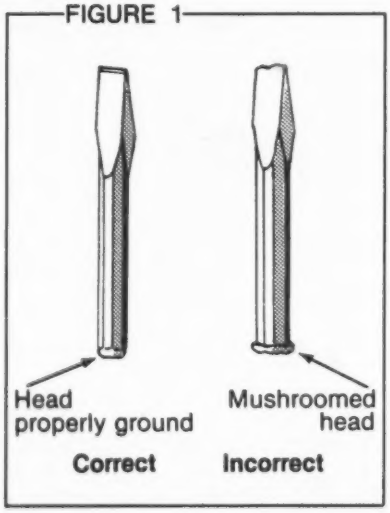
SUPPLEMENT 1

Guidelines for Using Cutting Tools

Chisels, punches, and impact drivers

- Wear goggles or safety glasses with side shields whenever using a punch, chisel, or impact driver.
- Hold the tool firmly and as closely as possible to a 90-degree angle to the surface being cut.
- Hit the head of the tool squarely and as centered as possible on the hammer.
- When cutting bolts or other objects with a chisel, make a guide cut with a hacksaw or with a few soft blows on the chisel before using forceful blows.
- Use the largest tool suitable for the job because the smaller the tool in relation to the workpiece the greater the chance of the tool slipping or bouncing.
- **Never** use a chisel, punch, or impact driver with a *mushroomed* head; grind heads to the correct shape before using them (Figure 1).

FIGURE 1



- Keep chisels, punches, and impact drivers properly sharpened.

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Files

- Choose the correct file for the work to be done.

  EXAMPLES: Coarse file for plastics and soft metals, fine file for smooth finishes and hard metals, double-cut file for faster, rough removal

- Always use a handle on the tang of the file because the tang is sharp enough to pierce your hand or wrist (Figure 2).

FIGURE 2

- Apply pressure on the forward, cutting stroke; raise the file away from the material as you pull it back.
- Hold the file with one hand on the point and one around the handle; use a firm grip but do not press down with a lot of pressure.
- Make slow, distinct strokes the full length of the file; make no more than one stroke per second.
- Keep the file clean by scrubbing the face with a file card or wire brush when it becomes clogged.
- Do **not** use a file as a pry bar, and do **not** hammer on it like a punch because the file can break very easily, shattering into bits.

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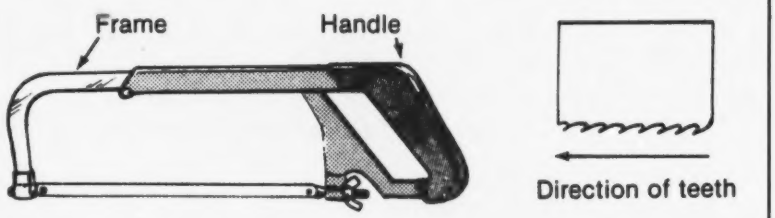
Hacksaws

- Mount the hacksaw blade securely with the teeth pointing away from the handle (Figure 3).

FIGURE 3



- Choose the correct blade for the material to be cut in a length that is convenient yet long enough to give a good cut.
- Make a couple of slow, light cuts to provide a guide cut.
- Hold the saw with one hand around the handle and the other around the front of the frame.
- Apply light downward pressure on the forward stroke and raise the saw from the material slightly on the backward stroke.
- Saw slowly and deliberately with no more than one stroke per second.
- Use a blade that has at least two teeth in contact with the material being cut to prevent binding and snagging.

Nut-splitters and tubing cutters

- Seat tool as squarely as possible.
- Tighten cutter and score fastener evenly.
- Allow the cutter to do the work; do **not** force cutter or overtighten.

Taps and dies

- Select the correct size tap or die for the required fastener.
- Use a tap drill chart to determine the correct diameter of hole.
- Drill hole at correct angle for proper alignment of fastener.

- Mount tap or die in correct wrench.
- Start tap or die carefully to be sure that cutter is correctly started.
- Turn tap or die one-half turn and then one-quarter turn back to break loose metal being removed.
- Apply cutting oil as the cut is being made.
- **Never** force a tap or die; if it becomes difficult to turn, back it off one or more complete turns and apply oil; if it is still difficult to turn after that, remove it from the hole or rod and examine the threads.

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SUPPLEMENT 2

Guidelines for Using Holding Tools

- Use the right size and type of tool for the job to be done.
- Do **not** use excessive force.
- Use only the handle that is on the clamp or vise; do **not** use other tools for increased leverage.
- Use only the power of your hands and arms to tighten a vise; do **not** try to put your full body weight on the handle.
- Use soft-jaw vises or wooden blocks with vises and C-clamps to prevent damage to parts and to distribute the pressure more evenly.
- Use pry bars **only** when recommended by the vehicle manufacturer.
- Use approved pry points.
- Apply force smoothly and evenly; do **not** jerk on pry bars.
- Check pry position frequently to make sure that pry bar is secure and has not slipped onto some part that can be damaged.
- Recheck alignment of parts after positioning with a pry bar.
- Be careful **not** to get wires, hoses, and other small parts pinched between part and holding tools.
- Make sure that you have a safe, secure footing before applying pressure.
- Check the area for sharp objects, electrical hazards, and dangerous substances such as air conditioning refrigerant lines before applying pressure with holding tools.

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SUPPLEMENT 3

Guidelines for Using Power Tools

- Keep air lines and electrical cords in good condition; do **not** use frayed, cracked, or otherwise damaged lines or cords.
- Do **not** operate any power equipment without being trained in its use and familiar with the operating instructions.
- Disconnect power to tools when not in use.
- Follow manufacturer's recommendations with regard to power source:

  Operate pneumatic tools at correct air pressure.

  Use grounded plugs and outlets for electrical tools.

  Use size and quality of air hoses and connectors recommended by manufacturer.

  Do not overload electrical boxes or extension cords.
- Be aware of limits for which power tools can be used, and do **not** exceed them.

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ACTIVITY SHEETS	USE COMMON HAND AND POWER TOOLS

ACTIVITY SHEET 1

Report on specialty tools

Name _____

INTRODUCTION

Automotive engineering often requires complex component designs in order to get parts to fit in the available space, to be held securely, or to operate properly. This leads to parts that are difficult to reach with regular tools and to parts that require special tools for removal. As a result, vehicle manufacturers frequently design special tools for use in repairing their vehicles. Service manuals refer to special tools in the procedure for which they are needed, usually by a code number.

DIRECTIONS

Your instructor will assign a report for you to make. The report may be made orally for the class or in writing for your instructor. In the report, you will study service manuals and specialty tools in order to see how such tools are referred to and how they are used.

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JOB SHEET 1

USE COMMON HAND AND POWER TOOLS

OBJECTIVE 6

Remove damaged threaded fasteners

INTRODUCTION

Many of the tasks performed by automotive service specialists require the removal or installation of fasteners. Frequently these fasteners will become damaged or will be difficult to remove. There are many reasons for this. Fasteners may become corroded or rusted. They may have been installed incorrectly. For example, someone may have *crossed threaded* the fastener—that is, forced the fastener even though the threads were not mated. This may occur because the fastener was improperly seated when installed or the fastener was damaged prior to installation. Another common problem is the broken fastener. Fasteners are broken—especially bolts installed in threaded holes—when they are overtightened during installation or during removal of a *frozen* fastener, one that has been cross-threaded or rusted in place. Because it is necessary to remove damaged fasteners in order to complete service requirements, a number of tools and procedures have been developed to remove damaged fasteners.

When deciding which procedure to use, you will need to consider several factors, such as the location of the fastener. It may be impossible to reach the fastener with some tools or using some procedures. The fastener may be located near the fuel tank, meaning that heat cannot be used to remove the fastener. The materials and tools that you have will also determine what procedure you will try. Another consideration is the damage that will be done to the fastener and the parts. Sometimes the fastener cannot be saved, but the specialist will generally try to save the fastener if possible.

The procedures that follow are divided into two groups: those for frozen fasteners and those for broken bolts, studs, and screws. The procedures are listed beginning with the simplest, least-destructive and going to more complicated and destructive techniques. You should practice as many of the procedures as possible.

Several types of tools are used for removing damaged threaded fasteners. Therefore, you should always follow the guidelines given in Student Supplements 1 through 3 when performing these types of procedures.

This job sheet will give you practice removing different kinds of damaged fasteners.

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EQUIPMENT AND MATERIALS

- Eye protection
- Wire brush
- Penetrating oil
- Heating torch
- Locking pliers
- Screwdriver
- Impact driver
- Hammer
- Socket wrenches
- Pipe wrench
- Hacksaw
- Punches
- Chisels
- Electric drill motor and bits
- Screw extractors
- Nut-splitter
- Various types of damaged fasteners including frozen nuts and bolts and broken bolts in tapped holes
- Nuts of various sizes to fit broken bolts or studs

PROCEDURE

For removing frozen nuts or bolts

- Using penetrating oil

NOTE: *Penetrating oil* is a special solvent that is used to break loose rusted and corroded parts. It is available in aerosol or nonaerosol sprays and liquid that can be poured or brushed on or applied with an oil can. Using it can often be enough to free nuts frozen by rust or corrosion. At other times, the use of penetrating oil may make it possible to free fasteners with other methods.

1. Scrub exposed part of fastener with wire brush to remove as much rust or corrosion as possible
2. Lightly tap side of fastener with hammer

CAUTION

Do **not** hit the threads.

NOTE: Sometimes a couple of taps will free a frozen fastener. You may want to try loosening it again after tapping it.

3. Apply penetrating oil liberally around threads or bolt head
4. Tap fastener again on side
5. Allow penetrating oil to set for several minutes before attempting to loosen fastener

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6. Attempt to loosen fastener using appropriate tool
7. Repeat procedure if necessary

- Using heat

NOTE: Metal expands when heated, so it is possible sometimes to break a nut free by heating it. Several sources of heat are available but the two most commonly used in the automotive shop are the oxyacetylene torch and the portable gas torch.

1. Carefully inspect area around fastener to be heated

► WARNING ◄

Do **not** use heat near flammable or combustible materials. Be especially careful around fuel tanks and lines, which can easily explode. Use care **not** to melt rubber-covered wiring, covers, and trim. Do **not** use heat around electronic equipment. Also be careful of flammable materials such as cloth, seats, carpeting, and cardboard backing.

2. Light torch and adjust flame following manufacturer's instructions
3. Apply heat to fastener, moving flame around fastener to heat evenly, and check area frequently for possible damage
4. Watch fastener for changes in color

CAUTION

Do **not** overheat fasteners. Steel fasteners may be heated safely to a dull red color. However, each situation must be treated differently. For example, aluminum is used for many parts and cannot withstand much heat without warping. Be careful when heating fasteners installed in aluminum.

5. Shut off flame and set aside torch

CAUTION

Set torch aside where it will not cause a fire or present a danger to others. Also, be careful not to burn yourself on the heated fastener and the area around it.

6. Lightly tap sides of fastener with hammer
7. Attempt to loosen fastener using appropriate tool
8. Repeat procedure or use different method for removing fastener if necessary

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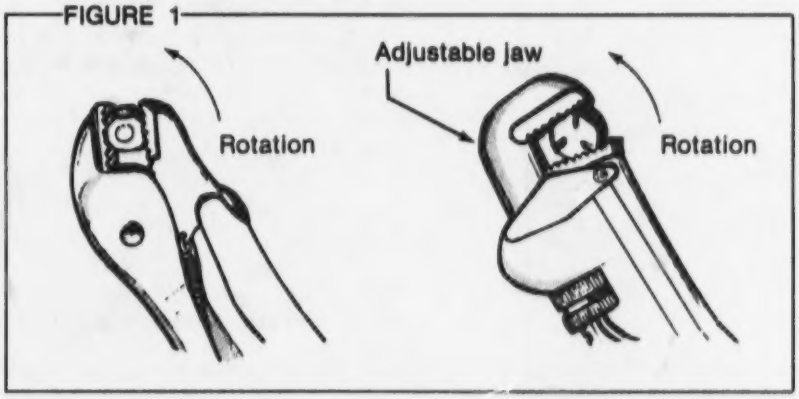
PROCEDURE

For removing rounded nuts and bolts

NOTE: Rounded nuts and bolts are those on which the corners of the bolt or on the outside of the nut have been rounded. This usually occurs when the incorrect tool or the wrong size wrench has been used during installation.

1. Adjust pipe wrench or locking pliers to size of nut or bolt head
2. Place wrench on nut or bolt head in such a way that adjustable jaw of tool will be on backside of fastener as it is turned; place locking pliers so that teeth are pointed in direction that fastener is to be turned (Figure 1)

FIGURE 1



3. Turn tool in appropriate direction to loosen fastener
4. Reposition tool and turn again, repeating as necessary to complete removal

PROCEDURE

For removing bolt or stud broken off in tapped hole

NOTE: If sufficient length of the bolt or stud sticks above the part, a pipe wrench or locking pliers may be used, as previously described, to remove bolt or stud.

- Using jam-nut method

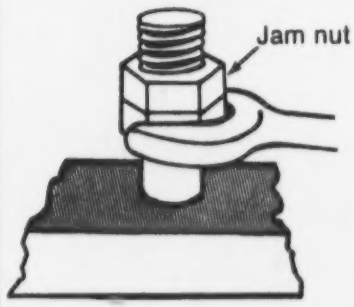
NOTE: The jam-nut method uses two nuts. One nut is used to "jam" against another, locking it in place so that a wrench can be used on it to remove the broken bolt or stud. Some service specialists prefer to weld a nut in place rather than using the jam-nut method.

1. Tighten first nut down on stud or bolt

2. Place second nut on stud or bolt and tighten down against first nut

3. Loosen bolt or stud by placing wrench on first nut and turning (Figure 2)

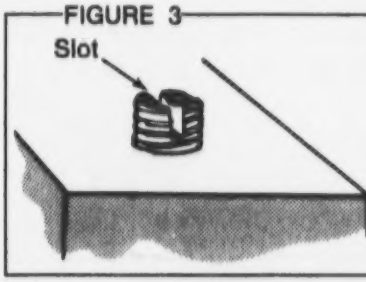
FIGURE 2



- Using screwdriver

1. Use hacksaw to cut slot in top of bolt or stud (Figure 3)

FIGURE 3



2. Use screwdriver or impact driver to turn fastener out

- Using screw extractor

NOTE: The extractor package will generally provide the information needed to determine the size of extractor required and the size of hole to be drilled.

1. Determine size of extractor required for fastener

2. Determine size of hole to be drilled for extractor

3. Drill hole in broken bolt or stud to be removed

4. Insert extractor and remove fastener

   NOTE: Various designs of extractors are available. Some are driven in with a hammer, while others cut into the sides of the bore in the fastener as they are turned.

   a. *If* using extractor with straight teeth, use hammer to insert extractor and socket wrench to remove fastener (Figures 4 and 5)

FIGURE 4

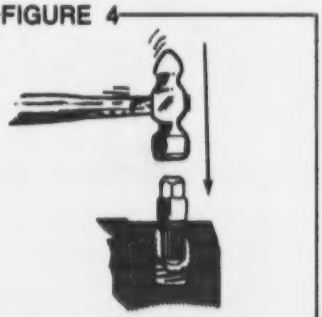
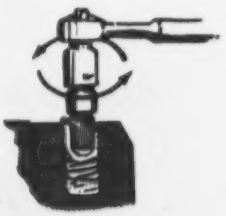


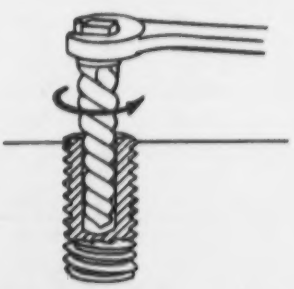
FIGURE 5



   b. *If* using twisted-type extractor, use wrench to insert extractor and remove fastener (Figure 6)

   NOTE: The twisted-type extractor is turned into the damaged fastener in the same direction in which the fastener must be turned for removal.

FIGURE 6



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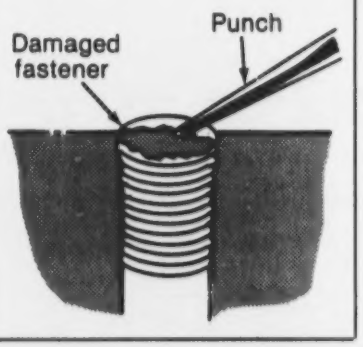
- Using punch

1. Place point of punch against top of broken stud
2. Hold punch at angle so that force of hammer blows will turn fastener from hole (Figure 7)

FIGURE 7



3. Hit punch lightly to turn fastener
4. Reposition punch, hit again, and continue procedure until enough of broken fastener is above part surface to allow use of another removal procedure
5. Remove fastener
6. Have instructor evaluate your work
7. Clean work area and return equipment and materials to proper storage

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JOB SHEET 2

USE COMMON HAND AND POWER TOOLS

OBJECTIVE 7

Tap a hole

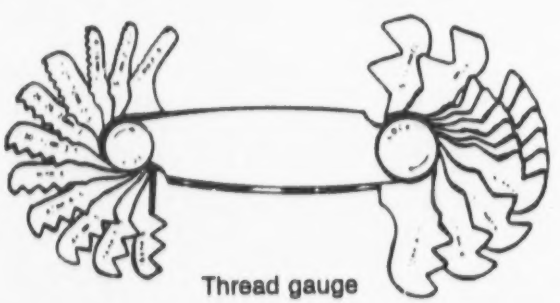
INTRODUCTION

Many parts are secured by bolts or studs in threaded holes. Occasionally, it may be necessary to thread a hole or rethread a damaged hole to accommodate a bolt or stud. The tool used to thread a hole is called a *tap*.

A tap cuts threads in the sides of an existing hole. First, the hole must be drilled or enlarged with a drill press or hand drill. Then the hole is *tapped*. In the automotive service trade the two most common occasions for tapping a hole are when it is necessary to thread a hole that has been enlarged or to thread a new hole. The tapping procedure is generally the same in either case, but the preparation is different. The following guidelines apply to either tapping situation.

- Follow all prescribed safety rules. Do not operate any power equipment unless your instructor has observed you using it and has approved your skill level.
- Determine the required thread and the correct size bore (drilled hole) for that thread. This is a critical step in preparing to tap a hole. Use a thread gauge as shown in Figure 1 below to determine the required thread by measuring the threads on the fastener. Then select a tap to match the fastener.

FIGURE 1



Thread gauge

- Consider the type of hole required when selecting a tap. If the hole goes all the way through the material, use a *tapered tap*. If the bore is a *blind hole*—that is, one that does not go completely through the metal—then use a *bottoming tap*.

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- If at all possible, drill the hole with a drill press. This will help in making an accurate cut. However, in some cases, it will not be possible or practical to remove the part on which you are working from the vehicle. For example, it may be a part that is very difficult to remove and the hole to be tapped is shallow. In such cases, it may be acceptable to use a hand drill. A hand drill may also be used on a removed part if a drill press is not available.

- Use cutting oil if necessary. Cutting oil should be used if tapping holes in hard metals, but it is not required when working with aluminum and cast iron.

Cutting, holding, and power tools may all be used when tapping a hole. Therefore, in addition to these guidelines, you should also observe the guidelines given in Student Supplements 1 through 3.

This job sheet will give you practice tapping a hole.

EQUIPMENT AND MATERIALS

- Eye protection
- Part to be tapped
- Set of taps
- Tap wrenches
- Set of drill bits
- Drill motor or drill press and manufacturer's manual
- Cutting oil if required
- Center punch
- Ball-peen hammer
- Drill and tap size chart
- Thread gauge
- Vise
- Steel rule or square

PROCEDURE

1. Prepare to drill hole

   a. *If* drilling new hole, locate center of hole to be drilled in part, and mark with punch

   b. Install proper size drill bit

      NOTE: When drilling new holes over 1/4 inch in diameter, you may want to drill a pilot hole of a smaller size and then drill hole to be tapped. Refer to drill manufacturer's instructions.

   c. Secure part in vise, if possible

      (1) *If* drilling new hole, clamp part in vice and position drill bit over punch mark

(2) *If* enlarging existing hole, clamp part in vice and position drill bit at correct angle so that bit is centered in existing hole

2. Apply cutting oil if required

3. Lower drill bit to punch mark or hole and start drill

   NOTE: If using a drill press, set speed in accordance with manufacturer's recommendations. You may also want to drill a center hole if you are drilling a new hole.

4. Continue drilling to required depth, maintaining correct angle

   NOTE: Drill motor and drill press accessories may include depth gauges so that you will know how deep a blind hole has been drilled. Otherwise, you should mark the drill bit to show you how deep to drill.

   CAUTION

   Do **not** force drill bit. Feed it into the material with steady pressure.

5. Withdraw drill when hole is complete

6. Turn off drill

7. Clean hole if required

8. Fasten tap securely in tap wrench

9. Put tap in hole and apply steady downward pressure while turning tap wrench clockwise; screw tap in hole about two turns

10. Loosen tap wrench and remove from tap, making sure **not** to move tap out of line

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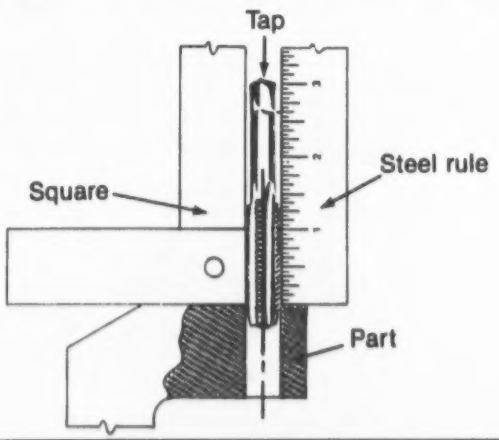
11. Check tap with steel rule or square to see that it is square to the part (Figure 2)

FIGURE 2



12. *If* tap is **not** square to the part, correct tap position
    a. Attach tap wrench and slightly back out tap from hole
    b. Straighten it by applying side pressure, and screw it back in hole
    c. Recheck for squareness
13. *If* tap is square and started in hole straight, apply cutting oil to the tap
14. Screw tap in hole one or two complete revolutions, and back it out one turn or until you feel the chip break

    NOTE: The tap must be backed off to free the removed material (chip) so that the chip will not interfere with the cutting process.
15. Continue to screw tap into part, backing out every few turns to break chips, until the tap turns freely and threads have been made through length of hole
16. Turn tap counterclockwise and remove tap from part
17. Remove tap wrench and clean tap
18. Have instructor evaluate your work
19. Clean work area and return equipment and materials to proper storage

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JOB SHEET 3

USE COMMON HAND AND POWER TOOLS

OBJECTIVE 8

Remove and install flared tubing

INTRODUCTION

Although hoses are used to carry many fluids in automotive systems, metal tubing is used for some applications, such as part of the fuel system and brake system. The proper installation of tubing requires patience and skill, but it is a procedure necessary for automotive service specialists to perform.

Metal tubing can wear through by rubbing against other parts, break or kink due to violent jolts, clog, or develop bad or corroded connections. These defects require replacement of the line or connections. Although hoses may not wear as easily as tubing, only in some cases can sections of defective tubing be replaced with rubber hose. However, in most cases you will want to replace metal tubing with similar line.

Metal tubing is joined together with threaded unions, which make secure, leakproof connections. The unions connect to tubing ends and are kept from slipping by a ridge of some sort around the tubing. Various designs are used. A tapered sleeve may be soldered on the line. Another method uses a tapered ring called a *ferrule*. The ferrule fits into the taper of the nut on the tubing and that inside the fitting. As the two halves of the coupling are threaded together, the ferrule is compressed onto the tubing. Some types of unions are shown below in Figure 1.

FIGURE 1

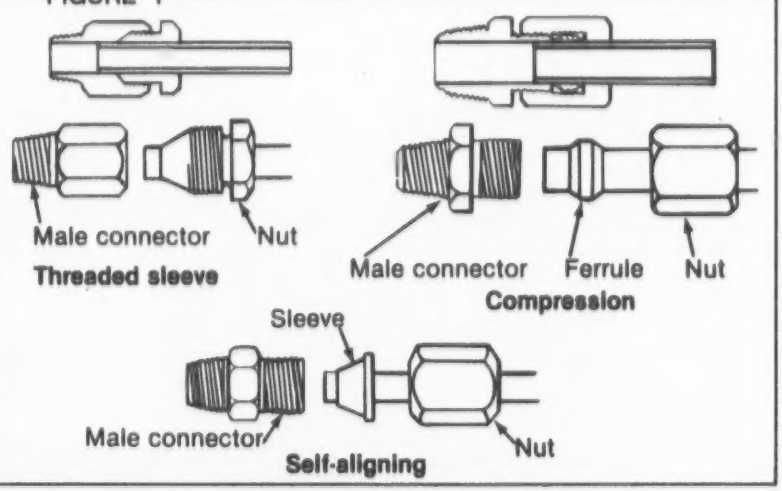

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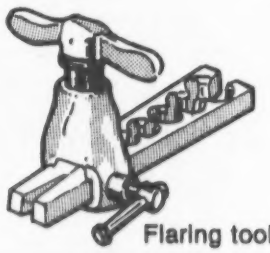
FIGURE 2



Flaring tool

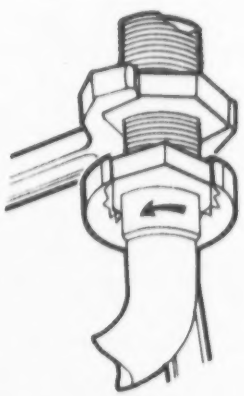
One of the most common methods of securing tubing unions is to *flare* the ends of the tubing. Flaring increases the opening at the end of the tubing. The tool that is used to flare tubing is shown in Figure 2.

Tubing and unions can be purchased in various materials. Tubing is even available in specific lengths with union nuts already installed for different applications. However, such lines are more expensive than making them yourself. In addition to following the guidelines given in Student Supplements 1 through 3, be sure to observe the guidelines below when working with metal tubing.

- Always follow proper handling procedures for the fluid carried by the line to be removed and replaced. Special care must be taken for pressurized lines, so be sure to refer to the manufacturer's service manual. Follow precautions you have learned previously for handling fuel. If removing brake lines, be careful not to get brake fluid on chrome or painted surfaces.

- Use tubing wrenches when removing or installing tubing (see Figure 3). This will prevent the tubing from twisting. When tubing is connected to a second nut, use two wrenches—one on each half of the union.

FIGURE 3



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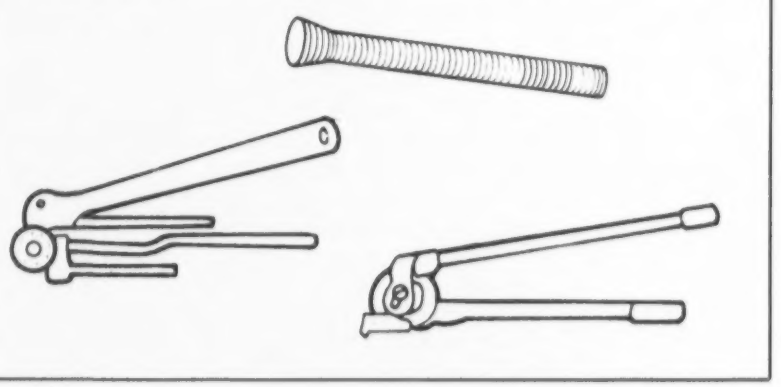
- Use replacement tubing of the same *inside* diameter and materials as the original line.
- Cut and shape the new tubing as closely as possible to the original line. There are various tools used to bend tubing, such as the spring bender and the levers shown in Figure 4.

FIGURE 4



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Most procedures that apply to the use of threaded fasteners also apply to tubing connectors. However, the installation of tubing does require that the service person be able to cut, flare, and bend tubing. This job sheet will provide you with practice to develop these skills.

EQUIPMENT AND MATERIALS

- Eye protection
- Original tubing
- Replacement tubing
- Unions
- Tubing cutter
- Basic hand-tool set
- Tape measure or string and ruler
- Chalk or scribe
- Reamer or round file

PROCEDURE

For cutting tubing

1. Select replacement tubing of correct diameter and type

2. Determine length of replacement tubing by measuring original section of tubing

   NOTE: Tubing lengths are specified in some service manuals.

   a. *If* original tubing is straight, measure straight pieces with a ruler or measuring tape

   b. *If* original tubing is curved or coiled, measure with a tape measure or by using a string to follow length and shape of line and then measuring string

3. Mark tubing with chalk or scribe line at point to be cut

4. Place tubing in cutter, positioning blade on mark

5. Rotate cutter around tubing while slowly tightening blade, being careful **not** to force cutter

6. Continue rotating cutter until cut is complete

7. Use reamer or round file to smooth newly cut end

PROCEDURE

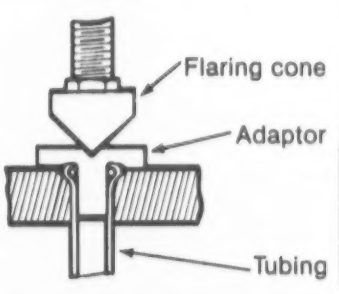
For flaring tubing

1. Place one end of tubing through appropriate hole of flaring tool with approximately 1/16 inch to 1/8 inch of tubing protruding

2. Determine correct size adaptor and slide into tubing end (Figure 5)

   NOTE: The size of adaptor used depends upon the diameter of the tubing.

FIGURE 5



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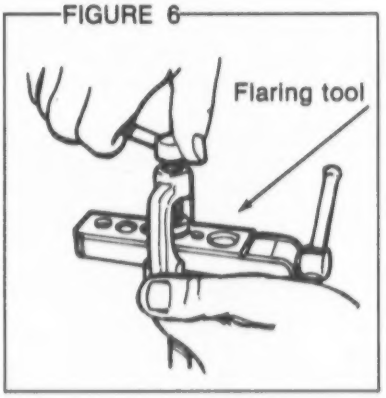
3. Tighten flaring cone down on adaptor to curl end of tubing inward (Figure 6)

FIGURE 6

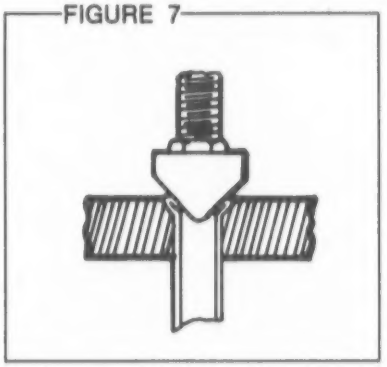


Used with permission of Chrysler Corporation.

4. Loosen flaring cone and remove adaptor

5. Tighten flaring cone once more so that cone point enters tube, pressing curled end of tube inward to complete flare (Figure 7)

FIGURE 7



Used with permission of Chrysler Corporation.

6. Loosen flaring cone, and remove tubing from flaring tool

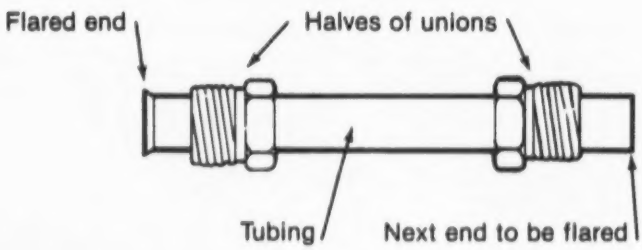
7. Select proper unions for connections at ends of tubing

NOTE: The type of unions selected for connections depends upon the diameter of the tubing.

1053

8. Place tubing halves of unions over tubing, being sure that fastener ends are correctly aligned (Figure 8)

FIGURE 8



9. Flare other end of tubing

PROCEDURE

For bending tubing

NOTE: Various tools exist to bend tubing; therefore, you must follow the procedures provided by the manufacturer.

1. Bend tubing following manufacturer's instructions
2. Have instructor evaluate your work
3. Clean work area and return equipment and materials to proper storage

1054

JOB SHEET 4

USE COMMON HAND AND POWER TOOLS

OBJECTIVE 9

Shape a chisel on a bench grinder

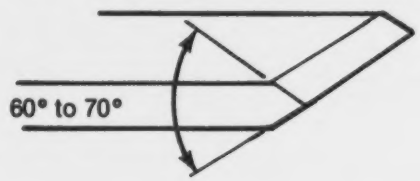
INTRODUCTION

An important part of the automotive service specialist's job is maintaining the tools used in the trade. Tools should be inspected frequently and always kept in good working order so that they can be used properly and safely.

One type of power tool that is used in the automotive trade is a bench grinder. A bench grinder is used for grinding and shaping, smoothing, and sharpening. This makes it useful for maintaining various hand tools, such as screwdrivers and chisels.

A chisel with a dull or chipped cutting edge cannot be used effectively, so the edge must be reshaped. The edge should be ground to an included angle of 60° to 70°. (Figure 1)

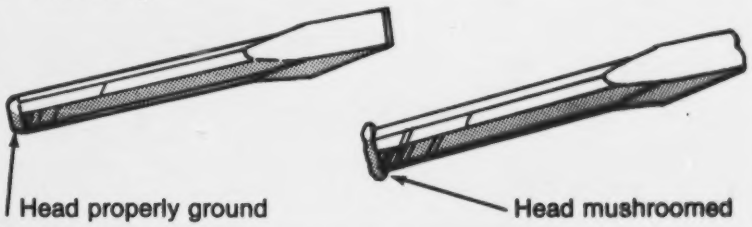
FIGURE 1



70° included angle

Chisel heads also become worn and misshapen from regular use. Mushroomed chisel heads present a danger in the shop because when the chisel is hit with a hammer, chips from the head can fly off and injure a worker or others in the area. Therefore it is also important to be sure to grind the chisel head to the proper shape. (Figure 2)

FIGURE 2



Using a bench grinder correctly is a valuable skill to you as an automotive service specialist. This job sheet will give you practice in using a bench grinder to shape a chisel. Although general safety rules apply, it is important that you observe the following guidelines, in addition to those listed in Student Supplements 1 through 3, when practicing this procedure.

- Always wear eye protection.
- Follow all general power-tool safety rules.
- Never use grinder with a cracked or damaged wheel.
- Always use tool rest and never force object being ground into grinding wheel.
- Alert others in the area if you are going to grind a chisel head that is mushroomed—chips may fly off during grinding.

EQUIPMENT AND MATERIALS

- Bench grinder
- Eye protection
- Chisel
- Container of water

PROCEDURE

1. Adjust grinder tool rest to proper clearance

   NOTE: Proper clearance is approximately 1/16 to 1/8 inch from grinding wheel.

2. Rotate grinding wheel by hand to make sure that it will clear tool rest

3. Turn on grinder

4. Grind head of chisel to proper shape, dipping head in water occasionally to keep it from getting too hot

   CAUTION

   When the head of a chisel is mushroomed, chips may fly off during grinding.

5. Grind cutting edge of chisel, dipping tip in water occasionally to keep it from getting too hot

   a. Rest chisel on tool rest, holding chisel at 60° to 70° angle with point against grinding wheel and handle pointing down

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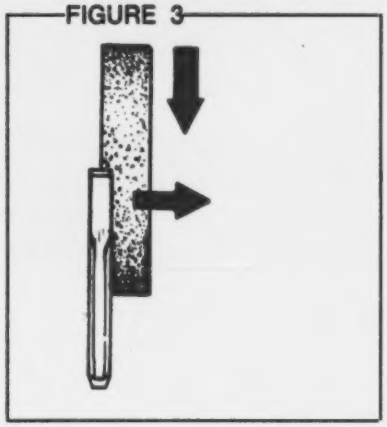
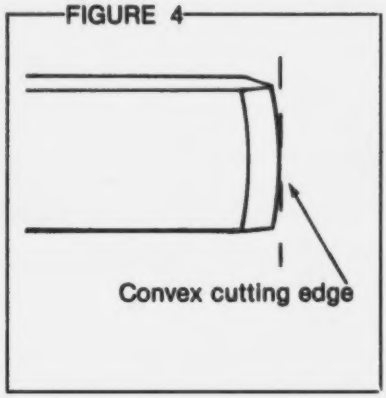
b. Applying slight pressure to grinding wheel, grind cutting edge of chisel by moving chisel point from side to side across grinding wheel (Figure 3)

FIGURE 3



c. Grind cutting edge slightly convex (Figure 4)

FIGURE 4



6. Turn off grinder
7. Have instructor evaluate your work
8. Clean work area and return equipment and materials to proper storage

1057

JOB SHEET 5

USE COMMON HAND AND POWER TOOLS

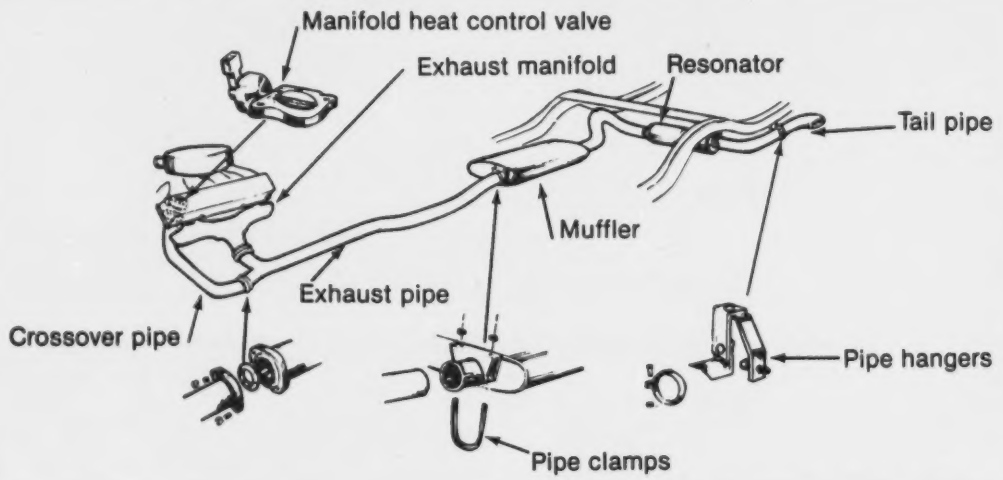
OBJECTIVE 10

Remove and replace exhaust system components

INTRODUCTION

The exhaust system is a vital part of any automotive design. Functions performed by the exhaust system include removing exhaust gases from the engine and routing them out the rear, thus protecting passengers from the toxic gases; helping to cool the engine by removing heat; converting some toxic gases to less toxic forms; quieting engine noise; and performing special functions, such as exhaust-driven turbochargers. As a result of having so many functions, the exhaust system consists of many components. A typical system is shown in Figure 1; however, this drawing is only one example of the hundreds of exhaust system arrangements used in vehicle designs.

FIGURE 1



Except for a few specialized parts, such as those used with turbochargers, exhaust system parts are not serviceable. Service consists primarily of replacing damaged or defective parts, tightening loose connections, and aligning parts to ensure that they do not contact other parts, such as the vehicle frame, brake lines, and fuel lines. The most common defects are those conditions that prevent exhaust gases from passing through the system or that allow gases to leak from the system before reaching the end of the tail pipe. Such defects can be extremely dangerous. For example, kinks or clogs that prevent the passage of exhaust gases will cause pressure to build up, which can lead to an explosion severe enough to damage the engine or other components. Leaks in the exhaust system can allow carbon monoxide and other poisonous gases to enter the passenger compartment.

The service specialist should observe several precautions when working on exhaust system components.

- Exhaust system parts can heat to well over 500°F during engine operation. Be sure that the system has cooled before touching any system parts.
- Many exhaust system parts are subject to rust buildup. This makes it particularly important to use eye protection and to be cautious when trying to remove rusted fasteners.
- After any service to the exhaust system, the service person must make sure that the system is leak-free and properly aligned.
- Some service techniques require the use of torches or welding equipment. Special care in the use of such heat-producing devices must be observed when working around fuel system components.
- Many exhaust system components, especially when assembled together, are quite heavy. You should get assistance from others or use lifting equipment when working with heavy components.
- Damaged or cut exhaust system components will often have sharp edges. Use care in handling such parts.

In addition to taking the precautions listed above, you should also follow the guidelines given in Student Supplements 1 through 3 when practicing this procedure.

This job sheet describes typical steps for removing and replacing exhaust system components. These steps will apply in a general way to most exhaust systems, but procedures described in service manuals must be followed.

EQUIPMENT AND MATERIALS

- Eye protection
- Hydraulic lift or jack and jack stands
- Basic hand-tool set
- Torque wrench
- Socket adaptor
- Penetrating oil
- Large flat file
- Cleaning solvent
- Appropriate replacement parts and gaskets
- Appropriate service manual

PROCEDURE

For removing and replacing exhaust manifold

1. Raise vehicle and support safely

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2. Saturate exhaust pipe flange fasteners with penetrating oil

3. Remove exhaust pipe flange fasteners, being careful to avoid twisting off manifold studs

4. Lower exhaust pipe away from exhaust manifold

5. Using penetrating oil on fasteners, remove crossover pipe if required, being careful to avoid twisting off any bolts or studs securing crossover pipe

6. Remove any tubing braces that may be connected to exhaust manifold

7. Apply penetrating oil to retainer bolts

8. Remove manifold retainer bolts, being careful to avoid twisting off any bolts or studs securing exhaust manifold

9. Remove exhaust manifold and check for cracks, warpage, rusted-through areas, or any restricted openings

   NOTE: *If* any of these conditions exist, the exhaust manifold should be repaired or replaced as necessary.

10. Clean mating surfaces of manifold with large file

    NOTE: File only enough to clean the surface. Avoid cutting extra metal from manifold surface.

11. Inspect gaskets; *if* damaged or worn, install new gaskets

12. Attach manifold; start retainer bolts, tightening in sequence to avoid distortion

13. Torque retainer bolts to manufacturer's specifications

14. Replace any braces or tubing that was removed

15. Clean mating surfaces of crossover pipe, if required, with file or cleaning solvent

16. Inspect gaskets; *if* damaged or badly worn, replace

17. Install crossover pipe if required, and tighten fasteners securely

18. Clean mating surfaces of exhaust pipe with file or cleaning solvent

1060

19. Inspect gaskets; *If* damaged or badly worn, replace

20. Install exhaust pipe; start fasteners

21. Check exhaust pipe alignment, making sure pipe does **not** contact frame, fuel lines, or hydraulic lines

22. Torque exhaust pipe fasteners to manufacturer's specifications

23. Lower vehicle to floor

24. Start engine

25. Check for leaks by using hands to feel any leaks

CAUTION

If leaks are present, they should be repaired at once.

PROCEDURE

For removing and replacing exhaust pipe

1. Raise vehicle and support safely

2. Saturate exhaust clamp fasteners and exhaust-pipe-to-muffler joint with penetrating oil

3. Remove clamp from exhaust pipe and muffler joint

4. Remove muffler from exhaust pipe

   NOTE: *If* muffler cannot easily be removed from the exhaust pipe, it may be necessary to use a chain wrench and heat to aid the breaking loose of the muffler joint.

5. Saturate exhaust pipe fasteners with penetrating oil

6. Remove exhaust pipe fasteners being careful to avoid twisting off the manifold studs

7. Remove any braces or hangers if required

8. Remove exhaust pipe

9. Clean mating surfaces of exhaust pipe and exhaust manifold

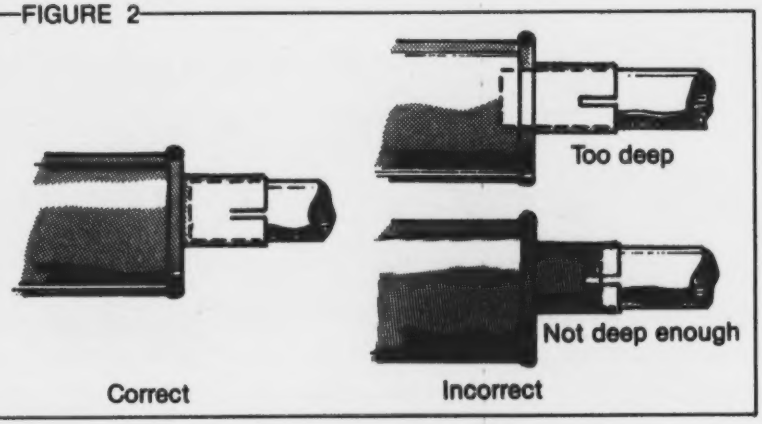
10. Inspect gasket; *If* damaged or badly worn, replace

11. Install exhaust pipe; start fasteners

1061

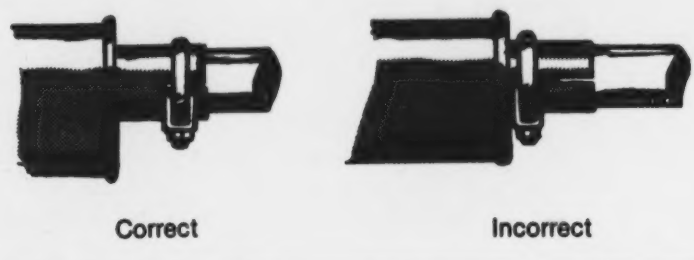
12. Position muffler on exhaust pipe (Figure 2)

FIGURE 2



13. Install exhaust pipe clamp; start fasteners (Figure 3)

FIGURE 3



14. Align exhaust pipe and muffler, making sure exhaust pipe and muffler do **not** contact frame, fuel lines, or hydraulic lines
15. Tighten exhaust pipe retainer bolts to manufacturer's specifications
16. Tighten exhaust pipe clamp securely
17. Replace any braces or hangers that were removed
18. Lower vehicle to floor
19. Start engine
20. Check for leaks

CAUTION

If leaks are present, they should be repaired at once.

1062

PROCEDURE | **For removing and replacing muffler**

1. Raise vehicle and support safely
2. Apply penetrating oil to muffler joints and exhaust clamps
3. Remove clamp at outlet end of muffler or exhaust hanger if necessary
4. Remove tail pipe from muffler

   NOTE: It may be necessary to use the chain wrench and heat to free the tail pipe from the muffler.

   a. *If* muffler is clamped to tail pipe, remove clamp at outlet end of muffler

   b. *If* muffler is welded to tail pipe, cut off tail pipe
5. Remove muffler from exhaust pipe

   NOTE: Use penetrating oil, tapping, and heat if necessary to free the muffler joint.

   a. *If* muffler is clamped to exhaust pipe, remove clamp at inlet end of muffler

   b. *If* muffler is welded to exhaust pipe, cut off exhaust pipe
6. Clean and straighten exhaust pipe and tail pipe if required
7. Replace muffler

   a. Slide muffler onto exhaust pipe

   b. Slide tail pipe into muffler (See Figure 2)
8. Install exhaust pipe and tail pipe clamps, and start fasteners on clamps (See Figure 3)
9. Position muffler on pipes, and tighten clamps slightly
10. Recheck position of muffler and alignment of exhaust system, making sure exhaust pipe, muffler, and tail pipe do **not** contact frame, fuel lines, or hydraulic lines
11. Inspect all clamps and hangers; *if* damaged or badly worn, replace

1063

12. Tighten exhaust clamps securely

13. Lower vehicle to floor

14. Start engine

15. Check for exhaust leaks by using hands to feel any leaks

CAUTION

If leaks are present, they should be repaired at once.

PROCEDURE

For removing and replacing a catalytic converter

CAUTION

Be sure converter has cooled before handling.

1. Raise vehicle and support safely
2. Remove heat shields from catalytic converter
3. Apply penetrating oil on fasteners
4. Remove converter inlet and outlet flange attaching nuts, being careful to avoid twisting off any bolts
5. Move muffler/tail pipe assembly rearward until converter can be removed
6. Remove catalytic converter
7. Replace catalytic converter
   a. Clean mating surfaces
   b. Install new gaskets
   c. Replace converter, and move muffler/tail pipe assembly forward until attaching surfaces are correctly aligned
   d. Install converter inlet and outlet flange attaching nuts and tighten securely
8. Install heat shields
9. Lower vehicle to floor
10. Start engine
11. Check for exhaust leaks by using hands to feel any leaks

CAUTION

If leaks are present, they should be repaired at once.

1064

PROCEDURE | **For removing and replacing tail pipe**

1. Raise vehicle and support safely on jack stands

   NOTE: It will be necessary to place the rear jack stands on the frame. This will allow the rear axle assembly to be lowered, thus providing room for tail pipe removal.)

2. Saturate outlet muffler joint, clamps, and hanger fasteners with penetrating oil

3. Remove tail pipe hangers

4. Remove tail pipe clamp

5. Remove tail pipe from muffler

   NOTE: Use the chain wrench, tapping, and heat if necessary to free the tail pipe joint.

6. Clean and straighten muffler outlet

7. Replace tail pipe

   a. Slide tail pipe into muffler

   b. Attach tail pipe to muffler

8. Replace clamps and start fasteners

9. Replace hangers and start fasteners

10. Position tail pipe and tighten clamps slightly

11. Recheck position of tail pipe and alignment of exhaust system

    NOTE: Make sure the exhaust pipe, muffler, and tail pipe do **not** contact the frame, fuel lines, hydraulic lines, or any body parts.

12. Tighten all clamps and hangers securely

13. Lower vehicle to floor

14. Start engine

1065

15. Check for exhaust leaks by using hands to feel any leaks

CAUTION

If leaks are present, they should be repaired at once.

16. Have instructor evaluate your work

17. Clean work area and return equipment and materials to proper storage

1066

JOB SHEET 6

USE COMMON HAND AND POWER TOOLS

OBJECTIVE 11

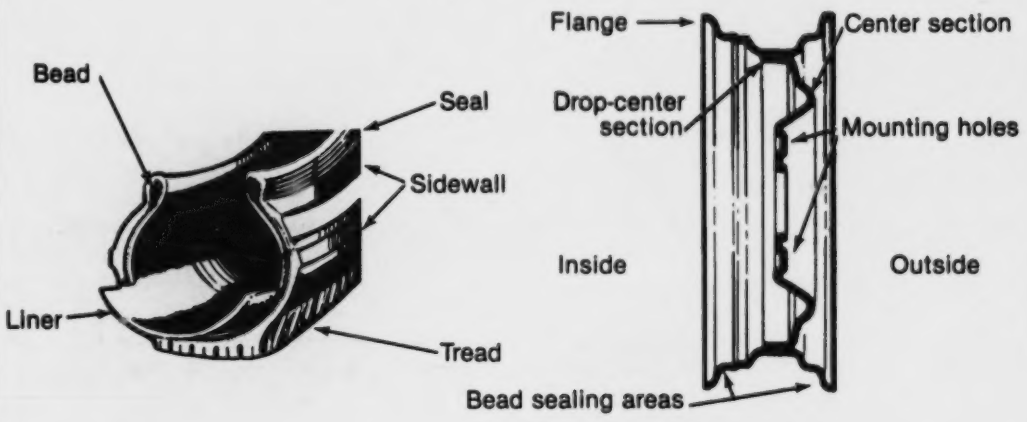
Remove, inspect, repair, and replace a tire on a wheel

INTRODUCTION

Many of the jobs available to automotive service specialists require skills in removing and installing tires. For example, the repair of flat tires, the replacement of wheels, and the installation of new tires are some of the tasks that require these skills.

The parts of a tire and a wheel rim are shown below in Figure 1.

FIGURE 1



(a) **Parts of a tire** (b) **Parts of a wheel rim**

Illustration (a) used with permission of Ford Motor Company. Illustration (b) used with permission of Chrysler Motors Corporation.

Most service facilities have specially designed equipment that assists with the removal and installation of tires. While the exact operation of such equipment varies with different manufacturers, the following principles apply to most brands:

- A prying tool is rotated about a shaft to separate the bead of the tire from the wheel. The process is repeated for the other side.
- Clamps, usually powered by compressed air, are used to squeeze the sides of the tires to move them past the rims of the wheels.

1067

- Compressed air, often assisted by mechanical devices, forces the bead area of the tire against the wheel rims.

- Many tire machines offer attachments or methods that permit the service person to work on the tire, such as spreading the walls of the tire to repair a puncture.

As with any piece of equipment, the service person must be knowledgeable of the operating procedures and familiar with the operator's manual for the particular tire machine being used. Some precautions, of course, should be observed:

- The compressed air used to operate tire machines and inflate tires is of high enough pressure to cause injury. Tires can explode if overinflated or can slip off the rim if not properly positioned.

- The clamps and other mechanisms used with tire machines operate with enough force to cause serious personal injury.

- Guards installed on tire equipment must be left in place and safety precautions provided by the machine manufacturer must be followed exactly.

The service specialist also must be able to correctly inspect and repair a tire. The following guidelines should be observed when performing these tasks.

- Carefully inspect a tire to be repaired, and determine if the tire meets all safety standards. If the tire does not, it is unsafe and should be replaced rather than repaired.

- Tires with cuts, holes, or abrasions on the sidewalls cannot safely be repaired.

- Check bead sealing surface for damage. If sealing surface is damaged, replace tire. In some instances a tire with such damage can still be used if an inner tube is used in the tire.

- Check opening on tire for valve stem to be sure it is not cracked or misshapen.

- Always check wheel rim to be sure it is not bent or damaged; a tire will not seat properly in a bent or damaged rim. Also inspect flange area. If rim is damaged, axial and radial runout should be checked with a dial indicator while tire is dismounted.

- To ensure proper tire-to-rim seal, clean with a wire brush areas of wheel rim that will contact tire bead.

1068

- Repair all types of tires with patches. However, plugs may be used for repair in emergency situations for bias-ply tires only—never for radial tires. Tires should be rebalanced after patching.
- When replacing a tire on a rim, always align match mark on tire (if present) with valve stem.

Study of this task and practice will allow the service specialist to become proficient at removing, inspecting, repairing, and replacing a tire on a wheel.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to tire machine manufacturer's manual and repair kit directions.

1069

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 1

Remove damaged threaded fasteners

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used correct removal procedures.	_____	_____
3. Used tools correctly.	_____	_____
4. Removed frozen fasteners following outlined procedure.	_____	_____
5. Removed rounded nuts and bolts following outlined procedure.	_____	_____
6. Removed bolt or stud broken off in tapped hole following outlined procedure.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1070

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1071

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 2

Tap a hole

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Determined required thread and the correct size bore for that thread.	_____	_____
3. Selected correct type of tap.	_____	_____
4. Used tools correctly.	_____	_____
5. Followed outlined procedure.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1072

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 · Skilled—Can perform job with no additional training
3 · Moderately skilled—Has performed job during training program; limited additional training may be required
2 · Limited skill—Has performed job during training program; additional training is required to develop skill
1 · Unskilled—Is familiar with process, but is unable to perform job

1073

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 3

Remove and Install Flared Tubing

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Selected correct replacement tubing.	_____	_____
3. Selected proper unions.	_____	_____
4. Used tools correctly.	_____	_____
5. Cut tubing following outlined procedure.	_____	_____
6. Flared tubing following outlined procedure.	_____	_____
7. Bent tubing following manufacturer's instructions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1074

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1075

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 4

Shape a chisel on a bench grinder

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used tools correctly.	_____	_____
3. Followed outlined procedure.	_____	_____
4. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1076

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1077

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 5

Remove and replace exhaust system components

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used tools correctly.	_____	_____
3. Removed and replaced exhaust manifold following outlined procedure.	_____	_____
4. Removed and replaced exhaust pipe following outlined procedure.	_____	_____
5. Removed and replaced muffler following outlined procedure.	_____	_____
6. Removed and replaced catalytic converter following outlined procedure.	_____	_____
7. Removed and replaced tail pipe following outlined procedure.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1073

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1073

PRACTICAL TEST

USE COMMON HAND AND POWER TOOLS

JOB SHEET 6

Remove, Inspect, Repair, and Replace a Tire on a Wheel

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used tools correctly.	_____	_____
3. Removed tire from wheel following procedure outlined in tire machine manufacturer's manual.	_____	_____
4. Inspected tire correctly, and properly evaluated tire condition.	_____	_____
5. Repaired tire following procedure outlined in repair kit directions.	_____	_____
6. Replaced tire on wheel following procedure outlined in tire machine manufacturer's manual.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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WRITTEN TEST

USE COMMON HAND AND POWER TOOLS

Name _____ Score _____

OBJECTIVE 1

Choose the definitions that best define the following terms. Write the correct numbers in the blanks.

_____a. **Gasket**

1. Exhaust system component which directs exhaust gases to the outside air
2. Flexible material used to seal areas between moving parts
3. Soft material used to seal areas between nonmoving parts

_____b. **Tire bead**

1. Material used to make radial tires
2. Inner portion of tire shaped to fit wheel rim
3. Outer surface of tire shaped in various patterns for different types of road conditions

_____c. **Penetrating oil**

1. Lubricant that flows between fastener threads to help in the removal of parts
2. Fluid used to cool, lubricate, or aid in removal of chips when cutting metal
3. Engine lubricant used with some of the late-model vehicles, especially sport cars

_____d. **Catalytic converter**

1. Exhaust system component which chemically changes harmful exhaust gases into harmless gases
2. Exhaust system component which directs exhaust gases to the exhaust manifold
3. Fuel system component which burns harmful gases, converting them to harmless gases

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_____e. **Saturate**

1. To clean a part or fastener by placing it in a container filled with cleaning solvent
2. To thoroughly soak or penetrate
3. Type of gasket used with tubing connections

_____f. **Pneumatic**

1. Powered by compressed air
2. Powered by electricity
3. Powered by movement and force of a liquid

_____g. **Cutting oil**

1. Lubricant that flows between fastener threads to help in the removal of parts
2. Fluid used to cool, lubricate, or aid in removal of chips when cutting metal
3. Engine-oil additive used when vehicle is "cutting out"

_____h. **Hydraulic**

1. Powered by compressed air
2. Powered by electricity
3. Powered by movement and force of a liquid

OBJECTIVE 2

Match the names of the types of cutting tools to the correct illustrations. Write the correct names in the blanks below the illustrations.

Punches	**Impact driver**	**Nut-splitter**
Hacksaw	**Chisels**	**Tap and die**
Cutting pliers	**Files**	**Tubing cutter**
Hand reamer		

a. _____

1083

b. _____

c. _____

d. _____

e. _____

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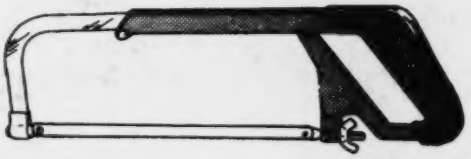
f. _____

g. _____



h. _____

i. _____

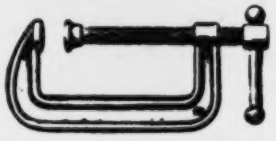
1085

j. _____

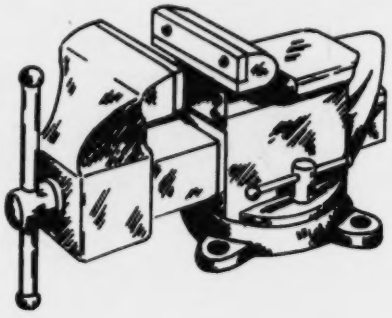
OBJECTIVE 3

Name each of the following types of holding tools. Write the correct names in the blanks below the illustrations.

a. _____



b. _____

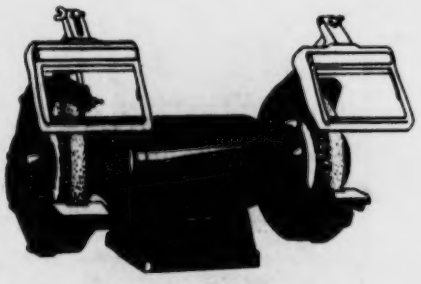


c. _____

1088

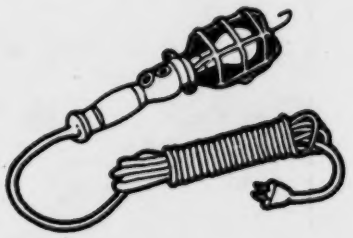
OBJECTIVE 4

Identify common power tools. Write the correct names in the blanks below the illustrations.



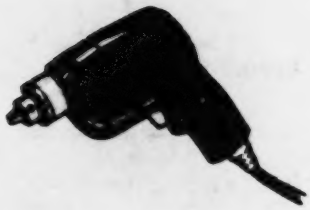
a. _____

b. _____



From *Introduction to Automotive Mechanics, Unit 1: Automotive Fasteners, Shop Equipment and Supplies*, rev. ed., ©1982 by State of Florida, Department of State. Used with permission of State of Florida, Department of State.

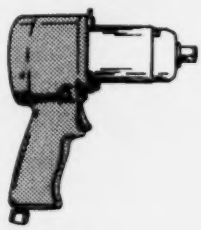
c. _____



d. _____

e. _____

f. _____



g. _____

1088

OBJECTIVE 5

Write the uses of each of the following tire and wheel tools.

a. **Bead lifter** — _____

_____

b. **Valve-stem remover** — _____

_____

c. **Lug wrench** — _____

_____

d. **Tire machine** — _____

_____

e. **Patching tools** — _____

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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WRITTEN TEST ANSWERS	USE COMMON HAND AND POWER TOOLS

OBJECTIVE 1

a. 3
b. 2
c. 1
d. 1
e. 2
f. 1
g. 2
h. 3

OBJECTIVE 2

a. Impact driver
b. Files
c. Chisels
d. Tubing cutter
e. Nut-splitter
f. Tap and die
g. Punches
h. Hacksaw
i. Hand reamer
j. Cutting pliers

OBJECTIVE 3

a. Pry bar
b. C-clamp
c. Vise

OBJECTIVE 4

a. Bench grinder
b. Air compressor
c. Trouble light
d. Drill motor
e. Air nozzle
f. Portable grinder
g. Impact wrench

OBJECTIVE 5

a. Used with tire machine to separate the tire from the wheel
b. Used to remove and install valve stems in tires
c. Used to remove lug nuts from lug bolts when removing wheel
d. Used to remove tire from wheel and to install tire on wheel
e. Used to repair tire punctures

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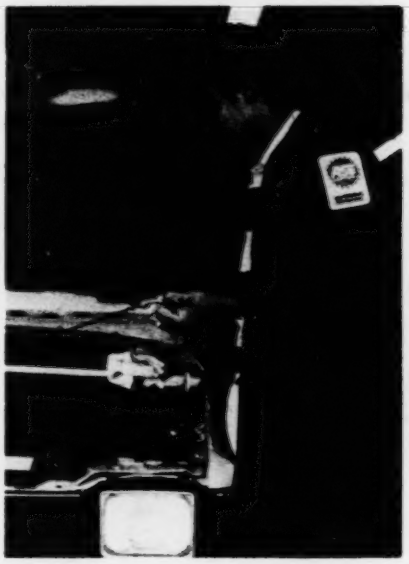
OBJECTIVE SHEET

UNIT B-4 MAINTAIN FLUIDS AND LUBRICANTS

INTRODUCTION



Fluids and lubricants in a vehicle are almost like the blood supply in a human body. Fluids and lubricants have many purposes. They serve a specific purpose in each system, such as transferring power in an automatic-transmission or brake system. But most fluids and lubricants also help to make parts work better, decrease wear, keep the system cooler, and prevent damage by cushioning parts. It is very important that the fluids used be of the right type, in good condition, and in enough quantity to serve these purposes. If not, the vehicle will not operate correctly and will not last as long as it could.

The service specialist must know how to select, use, and maintain vehicle fluids and lubricants.

UNIT OBJECTIVE

After completing this unit, the student should be able to maintain automotive fluids and lubricants. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit B-3, "Use Common Hand and Power Tools."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with maintaining fluids and lubricants by choosing the correct definition from a list of four choices.
2. Recognize the nature and purpose of automotive fluids and lubricants by matching fluids and lubricants to their correct descriptions.
3. Lubricate steering and suspension systems. (Job Sheet 1)

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4. Lubricate driveline components. (Job Sheet 2)

5. Explain the meaning of engine-oil ratings by completing statements about those ratings.

6. Change engine oil and filter. (Job Sheet 3)

7. Change engine oil in a vehicle equipped with a turbocharger. (Job Sheet 4)

8. Recognize how automotive fluids are identified by choosing the correct description from a list of four choices.

9. Interpret fluid and lubricant charts by answering questions about the fluid and lubricant requirements of specific vehicles. (Assignment Sheet 1)

10. Adjust fluid levels. (Job Sheet 5)

11. Flush cooling system. (Job Sheet 6)

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SUGGESTED ACTIVITIES	MAINTAIN FLUIDS AND LUBRICANTS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Display posters, charts, safety signs, etc., that emphasize fluids and lubricants. Have articles, specification guides, mock-ups, and other references about fluids and lubricants available for student use. Display various types and brands of fluids and lubricants.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

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DELIVERY

Unit introduction

- Discuss introduction to the unit (see "Objective Sheet").
- Discuss the booklet "The Inside Story: 11 Fluids That Keep Your Car on the Go."
- Use Transparency 1, "Fluid Systems," to illustrate the importance of fluids in vehicle operation.
- Display components that have been ruined or excessively worn due to neglect of fluid and lubricant maintenance.
- Show the class sample lubrication charts and service schedules from service manuals to show that fluid and lubrication requirements are very common.
- Tour the shop and point out equipment and materials involved in the maintenance of fluids and lubricants.

Objective 1 Recognize definitions of terms associated with maintaining fluids and lubricants

- Point to examples that illustrate terms in the shop and make examples available in the classroom.
- Show samples of various types of fluids.
- Demonstrate lubrication by holding a large screwdriver by the blade between your thumb and index finger. Then dip the screwdriver blade in engine oil and repeat the demonstration.
- Show a cutaway of an oil filter or demonstrate filtration through a filter element. Point out oil filters on various vehicles.
- Demonstrate the difference in viscosity between SAE 5 and SAE 40 engine oils.
- Discuss the term *inhibitor*. Show an oil pan with sludge deposits and a cutaway of a radiator with corrosion and deposits.
- Discuss other examples of the term *sustained* as it is used in the automotive trade.
- Show an example of an acid-pitted component. Discuss acids found in automotive systems and demonstrate what such acids can do to automotive materials.

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Objective 2 Recognize the nature and purpose of automotive fluids and lubricants

Lubricants

- Provide the class with samples of each type of lubricant.
- Use sandpaper and a soft substance to demonstrate how friction can produce wear. Then introduce a lubricant to reduce friction.
- Show an example of a limited-slip-differential lubricant and references in service or owner manuals requiring such lubricants.
- Use Transparency 2, "Lubrication Points," and lubrication charts to point out lubrication points. Relate such points to the type of lubricant required.
- Invite a fluid and lubricant manufacturer's or distributor's representative to talk to the class about such products.
- Use Moog's "Chassis Parts Wall Chart" or other aids to discuss how steering and suspension parts work and where they need to be lubricated.
- Discuss tools and equipment used in Job Sheet 1, "Lubricate Steering and Suspension Systems." Review with students applicable safety rules and precautions and guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 1, "Lubricate Steering and Suspension Systems."
- Have students practice Job Sheet 1 until they are ready to take the practical test.
- Show the media programs *Rear Axle and Drive Shaft Principles of Operation* and *U-Joint Failure Part 1—Lack of Lubrication.*
- Discuss tools and equipment used in Job Sheet 2, "Lubricate Driveline Components." Review with students applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 2, "Lubricate Driveline Components."
- Have students practice Job Sheet 2 until they are ready to take the practical test.

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Fluids

- Provide the class with samples of each type of fluid.
- Use samples of ATF, brake fluid, and power-steering fluids and mock-ups to introduce the concept of hydraulics.
- Use media programs such as *Theory of Hydraulics* and *Brake Hydraulics* to expand on the concept of hydraulics.
- Use Supplements 1, "Hydraulic Brakes," and 2, "Pumps," to discuss brake hydraulics and pumps. Emphasize the hydraulic principles involved in pumps even when the fluid being pumped is not a hydraulic fluid. Also discuss lubricating properties of fluids in pumps.
- Be sure that students understand that most fluids serve more than one purpose in a system.
- Discuss the various types of ATF and associate them through reference manuals to specific vehicle manufacturer's and transmission models; discuss symptoms and problems resulting from use of an incorrect ATF.
- Demonstrate the effects of fluids on painted and chrome surfaces, especially the effects of brake fluid.

Objective 5 Explain the meaning of engine-oil ratings

Viscosity rating

- Discuss Supplement 3, "Engine Lubrication."
- Use several grades of engine oil to demonstrate engine-oil viscosity. Also demonstrate the difference in oil performance at different temperatures by pouring an oil at room temperature and a sample of the same viscosity oil that has been refrigerated.

Service rating

- Use Supplement 4, "Lubricant Additives," to discuss additives.
- Discuss API ratings. Point out API requirements in service manuals of several different years. Emphasize that a higher API rating can be used to replace a lower rating, but substitution the other way cannot be done.

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- Use Transparencies 3, "Oil-Can Markings," and 4, "Oil-Bottle Markings" and actual oil containers to discuss container markings. Use a variety of brands, grades, and additive formulas, including synthetic blends and special formulas.

- Discuss booklet *Ten Commandments of a Filter Change*.

- Discuss tools and equipment used in Job Sheet 3, "Change Engine Oil and Filter." Review with students applicable safety rules and precautions and guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 3, "Change Engine Oil and Filter."

- Have students practice Job Sheet 3 until they are ready to take the practical test.

- Use Supplement 5, "Supercharging," to discuss supercharging.

- Discuss tools and equipment used in Job Sheet 4, "Change Engine Oil in a Vehicle Equipped with a Turbocharger." Review with students applicable safety rules and precautions and guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 4, "Change Engine Oil in a Vehicle Equipped with a Turbocharger." Be sure to emphasize oil-pressure buildup procedures and other operating considerations for turbocharged vehicles.

- Have students practice Job Sheet 4 until they are ready to take the practical test.

- Exhibit various types of filters.

- Discuss the use of low-quality oil and filters.

Objective 8 Recognize how automotive fluids are identified

- Display various types of ATF and use service manuals to discuss their use. Emphasize that although these fluids may be used in various systems, such as transfer cases, transmissions, and power-steering systems, the service specialist cannot assume that any particular system will use ATF.

- Display various types and DOT grades of brake fluids. Point out differences on the labels.

- Use service manuals to point out the need for specific power-steering fluids.

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- Have students complete Assignment Sheet 1, "Interpret Fluid and Lubrication Charts," and discuss in class.

- Discuss tools and equipment used in Job Sheet 5, "Adjust Fluid Levels." Review with students applicable safety rules and precautions and guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 5, "Adjust Fluid Levels."

- Have students practice Job Sheet 5 until they are ready to take the practical test.

- Use Transparency 5, "Antifreeze Protection Chart," to discuss the need for antifreeze.

- Demonstrate the expansion of frozen water by freezing a quart jar full of water.

- Discuss Supplement 6, "Engine Cooling." Show media *Cooling Systems* or *Efficient Cooling Systems*.

- Emphasize the need to match antifreeze additives to systems, such as the special corrosion-protection needs of aluminum blocks.

- Display and discuss *Cooling System Handbook*.

- Discuss tools and equipment used in Job Sheet 6, "Flush Cooling System." Review with students applicable safety rules and precautions and guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 6, "Flush Cooling System."

- Have students practice Job Sheet 6 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, "Recommend Fluid and Lubricant Service." The purpose of the activity is to provide students with the opportunity to think about fluid and lubrication service in terms of customer needs. Students will need to apply not only technical knowledge but also customer-relation skills. Keep this in mind when discussing the assignment.

- Have students complete Activity Sheet 1.

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EVALUATION

- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Armstrong, Ivan J. *Auto Mechanics, Volume I.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1976.
- Armstrong, Ivan J. *Auto Mechanics, Volume II.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1978.
- *Chilton's Auto Repair Manual, 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics,* 9th ed. New York: Gregg Division, McGraw-Hill Book Company, 1985.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Mitchell Information Services, Inc. *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.

Resources to be used as student references

NOTE: The materials listed below were used as resources in preparing assignment sheets and other components that require information and specifications for specific makes and models of vehicles. Copies of these materials may be required by students in completing such assignments.

- Chevrolet Motor Division, General Motors Corporation. *1986 Shop Manual: Caprice, Monte Carlo,* and *El Camino.* Warren, Michigan: General Motors Corporation, 1986.

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- Chevrolet Motor Division. *1985 Shop Manual: Light Duty Truck, 10-30 Series.* Warren, Michigan: General Motors Corporation, 1985.

- *Chilton's Auto Repair Manual, 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.

- Chrysler Corporation. *150-400 Series Truck Service Manual, 1980.* Detroit, Michigan: Chrysler Corporation, 1979.

- Chrysler Corporation. *1985 Front Wheel Drive Service Manual.* Detroit, Michigan: Chrysler Corporation, 1984.

- Mitchell *Transmission Service and Repair, 1984 Edition.* San Diego, California: Mitchell Manuals, Inc., 1984.

Media

- *Brake Hydraulics.* (AU-911) 83 slides with a 15-minute audiotape. Wagner Division, McGraw-Edison Company, 6400 Plymouth Avenue, St. Louis, Missouri 63133. This program explains how hydraulics is used in both drum- and disc-brake systems.

- *Theory of Hydraulics.* Slide/tape, 15 minutes. Dana Corporation, School Assistance Program, P.O. Box 455, Toledo, Ohio 43692. This program describes the concepts of flow, pressure, and force in a hydraulic system.

- *Cooling Systems.* 8 mm film, 15 minutes. Bar's Leak Western, Inc., 226 S. 24th St., P.O. Box 3217, San Jose, California 95116. The program shows the parts of a cooling system and their functions. The film also deals with cooling-system chemicals, such as flushing agents and leak sealers. The company will provide the film and projector free of charge.

- *Rear Axle and Drive Shaft Principles of Operation.* 83-frame, color filmstrip, 23 minutes, with record or cassette. Ford Motor Company, Fort Parts and Service Division, Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207. This program discusses the parts and operation of the rear-drive axle and the drive shaft. An accompanying student text is available.

- *U-Joint Failure Part 1—Lack of Lubrication.* Slide/tape. Dana Corporation (See *Theory of Hydraulics* for address.) This program discusses typical U-joint failures that result from inadequate lubrication and driveline lubrication procedures.

1100

- *Efficient Cooling System.* 16 mm, color, 12 minutes, 1974. Deere and Company. John Deere Road, Moline, Illinois 61265. This film discusses the function and maintenance of the cooling system.

  NOTE: *Efficient Cooling System* is available to Oklahoma teachers on a free-loan basis. Oklahoma teachers may order this film from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, OK 74074. Out-of-state teachers must order this film from the address listed.

Print media

- "The Inside Story: 11 Fluids That Keep Your Car on the Go." Booklet, order number AH4133. Fram Corporation, Automotive Division, 105 Pawtucket Avenue, East Providence, Rhode Island 02916.

- "Ten Commandments of a Filter Change." Chart. J. A. Baldwin Manufacturing Company, P.O. Box 610, Kearney, Nebraska 68847.

- "Cooling System Handbook." 24 pages. McQuay-Norris, Inc., Aftermarket Division, 2320 Marconi Avenue, St. Louis, Missouri 63110. This handbook describes the parts of the cooling system, their functions, and maintenance.

- "Chassis Parts Wall Chart." Moog Automotive, Inc., Moog Training Center, 6565 Wells Avenue, St. Louis, Missouri 63133. This chart consists of several pages of illustrations, including exploded views of various types of steering and suspension designs.

- Transparencies and competency profiles

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.

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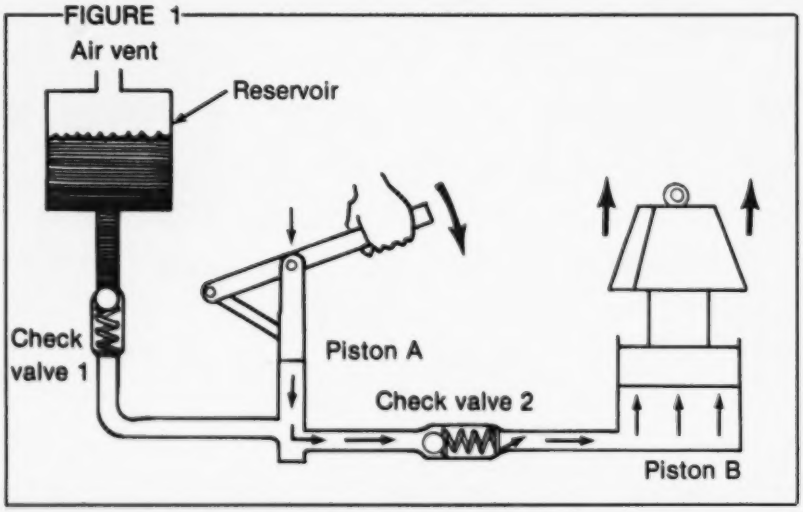
SUPPLEMENT 1

Hydraulic Brakes

Hydraulics is the use of a liquid to transmit power. For example, if you have a hydraulic jack similar to the one in Figure 1 below, you apply power to the jack by pumping the handle. The handle is attached to a rod (piston A) that pushes down on liquid—hydraulic fluid—in the pump. Unlike air, a liquid will not compress if pressure is applied to it in a closed container. If the hydraulic jack were a completely closed container, the handle would not move when you pushed down on it. For this reason, the jack has check valves in it. When you press down on the handle and apply pressure to the system, the hydraulic fluid forces check valve 2 open, pushing the ball against the spring. Hydraulic fluid flows past the valve and pushes piston B up. Raising the jack handle up leaves the chamber or cylinder under piston A empty. Without liquid in the cylinder, the fluid pressure in the reservoir is greater than the spring. So fluid from the reservoir moves past check valve 1 and fills the cylinder under piston A. Now the system is ready to pump again.

FIGURE 1



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The jack illustrates the components of any hydraulic system: a reservoir to hold fluid, a means of applying power to the system, fluid for transmitting the power, tubes or cylinders to route the fluid, valves to control the power, and pistons to transfer the power between the hydraulic system and another system, usually a mechanical one. By careful use of hydraulic principles, the power put into an hydraulic system can be moved from one place to another or to several other places. By using different sizes of pistons, the force that is put into the system can be increased or reduced.

Hydraulics is used in several ways in automotive systems. One such use is the brake system. Through hydraulics, the force of the driver's foot on the brake pedal is transferred and increased so that pressure is put against each wheel to slow down the vehicle. If the pressure is applied long enough, the wheels will stop turning and the car will stop. As stated earlier, the power source is the brake pedal that moves a piston in the master cylinder, which serves as the fluid reservoir. Valves in the distribution block or elsewhere control fluid flow, ensuring that power goes to each wheel. At each wheel cylinder, pistons transfer power to mechanical linkages. These linkages move the friction surfaces of the brakes to stop the wheels.

For the brakes to work properly, the whole system must operate correctly. There must be enough fluid and that fluid must be free of air pockets. The system should not leak and mechanical linkages should not bind. These are a few of the things you must check in the hydraulic brake system.

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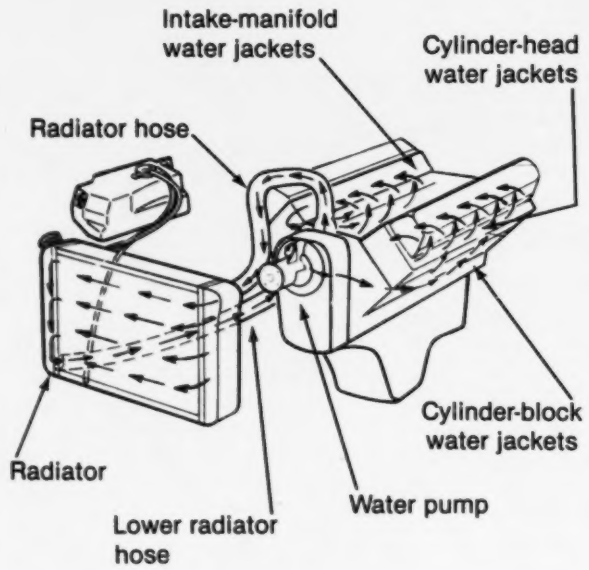
SUPPLEMENT 2 — Pumps

FIGURE 1



Pumps are devices used to move liquids through a system. Modern vehicles are equipped with several pumps. Both the engine cooling system and the engine lubrication system use pumps. The water pump in Figure 1 moves the coolant mixture through the cooling system. The pump is powered by the fan belt, and the turning impellers inside the water pump act like a paddle wheel to move the coolant from one side of the pump to the other.

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Engine oil pumps (see Figure 2) are powered by gears. The gears are usually driven by shafts that are connected to other shafts, such as the engine camshaft. Oil is moved through the pump either by gears or by rotors.

- In the rotor design (see Figure 2), a star-shaped inner gear turns inside a ring gear that is offset slightly from the inner gear. The offset difference means that the space varies between the inner and outer rotors. This creates a squeezing effect as the large oil-filled space rotates into a closer fit.
- In the gear design (see Figure 2), oil flows into the gear chamber from one side and is forced out the other side by the turning of the gears.

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FIGURE 2

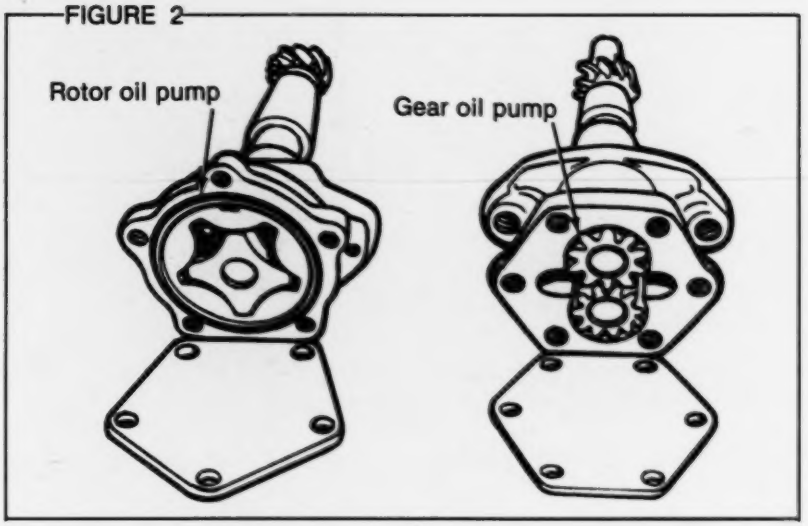

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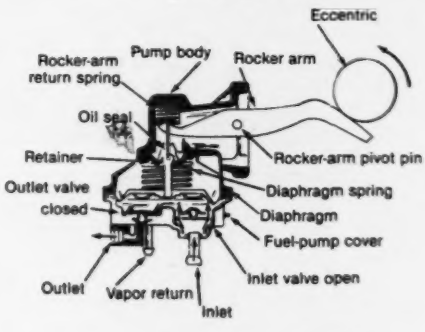
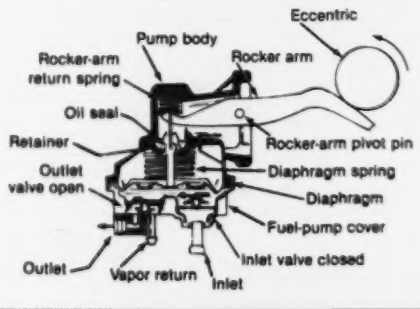
FIGURE 3





The fuel pump generally uses yet another type of pumping action. A mechanical fuel pump (see Figure 3) has a rocker arm that is in contact with a cam, often an extra lobe on the valve camshaft. The turning of the cam pumps the rocker arm much as you manually pump the handle on a hydraulic jack. Movement of the rocker arm and movement of a return spring cause a flexible diaphragm to move up and down. The diaphragm, a thin sheet of rubber or other flexible material, changes the pressure in the fuel chamber of the pump. This pulls fuel in on the intake stroke and forces it out on the output stroke. Some mechanical fuel pumps are serviceable, while others are not.

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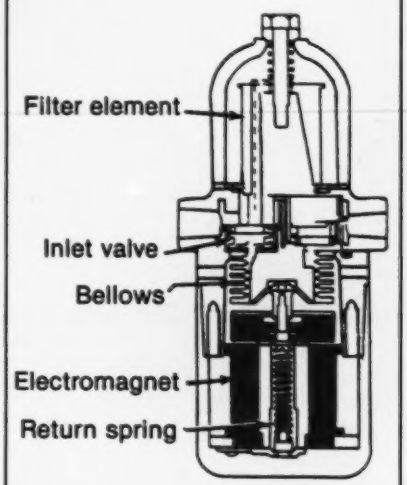
FIGURE 4



Many vehicles now come with electric fuel pumps, especially those with fuel-injection systems. Electric fuel pumps produce the high pressure required for fuel injection. Electric fuel pumps come in a variety of designs. One type uses impellers similar to the design commonly used for water pumps. Another design, shown in Figure 4, uses a flexible bellows and is similar in operation to the mechanical pump with a diaphragm.

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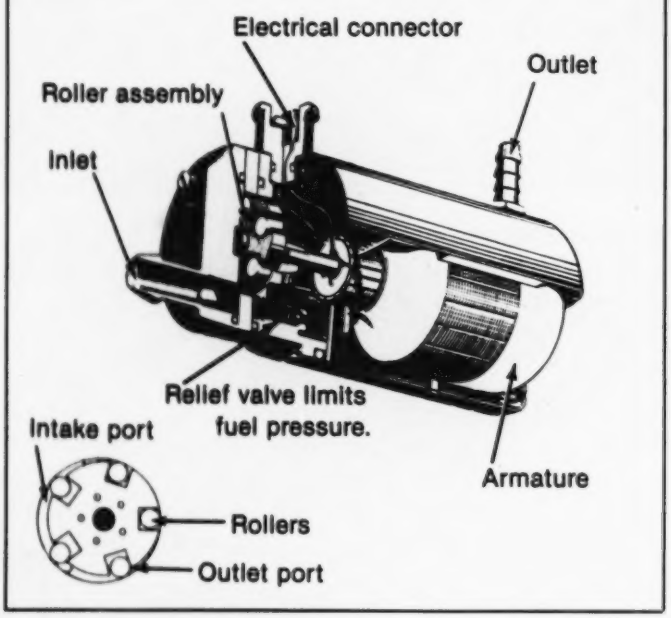
FIGURE 5



Two other types of electric fuel pumps use a rotor set slightly offset in a chamber. As the rotor turns, the offset causes the space between the rotor and chamber wall to vary, creating a squeezing action similar to that used in rotor-design oil pumps. The rotor may have rollers, such as those shown in Figure 5, or it may have vanes. Rollers and vanes serve the same purpose. They contact the chamber wall as the rotor turns. This helps to move fuel through the pump.

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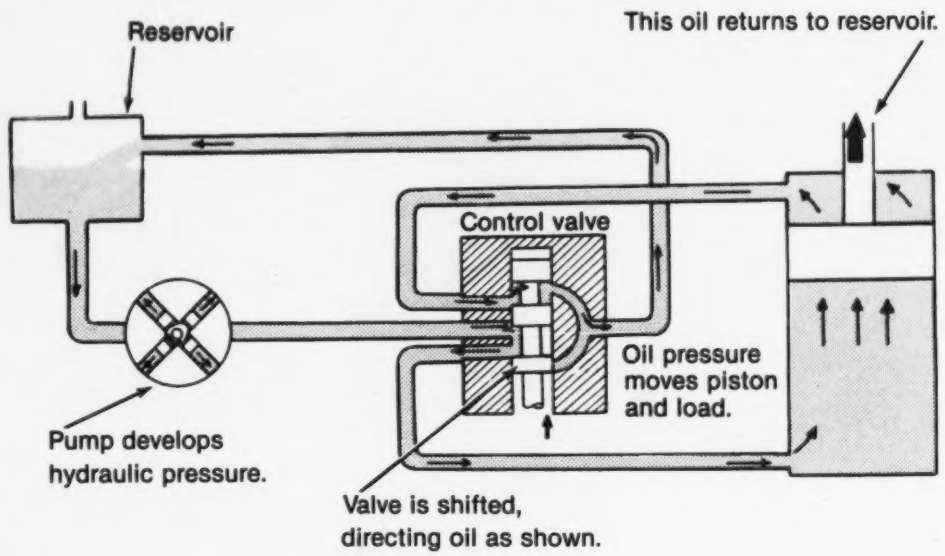
The power-steering system also uses a pump. In most designs, the pump is powered by an engine-driven belt. Figure 6 below shows a simplified drawing of a power-steering hydraulic system. Power produced by the system moves linkages that turn the wheels.

FIGURE 6


Reservoir
This oil returns to reservoir.
Control valve
Oil pressure moves piston and load.
Pump develops hydraulic pressure.
Valve is shifted, directing oil as shown.

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A power-steering pump may use a gear or rotor design. The rotor design may have vanes, rollers, or slippers (plunger-type devices similar to vanes).

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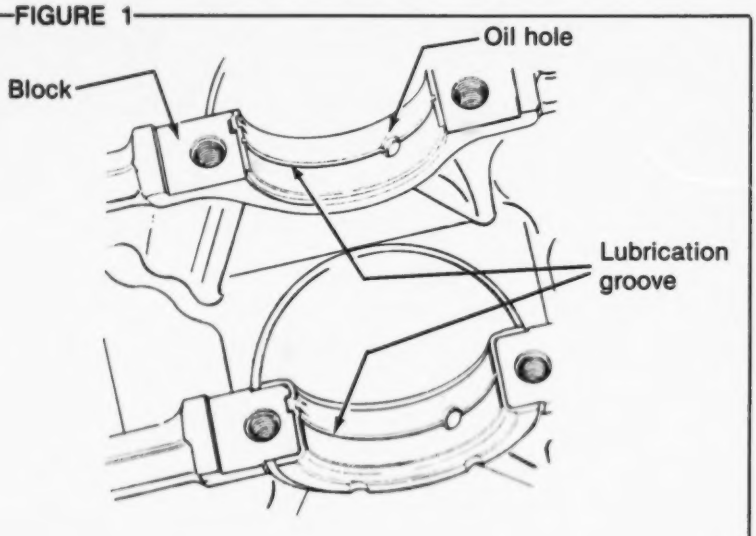
SUPPLEMENT 3

Engine Lubrication

As an engine operates, the moving parts rub against each other. In order to make the parts move more easily and to cushion the blow between parts that hit each other, the lubrication system coats the moving parts with oil. The oil also helps cool metal in the engine and reduce wear and corrosion of the parts. Finally, engine lubrication helps to clean engine parts and to form a seal between the piston and cylinder walls.

Engines are designed so that oil flows through the engine, reaching all parts that need to be oiled. In most designs, engine oil is stored in the *oil pan*. From there it is moved by an electrically or mechanically driven pump through *channels* or *galleries* to other parts of the engine. As it moves to the galleries, the oil often passes through a filter, which removes bits of metal, dirt, and other particles that would interfere with lubrication.

FIGURE 1



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Various methods are used to distribute oil inside the engine. The moving parts push, squeeze, and sling the oil to other surfaces. These parts are often designed with spurt holes and grooves that help channel the oil where needed, as shown in Figure 1 above.

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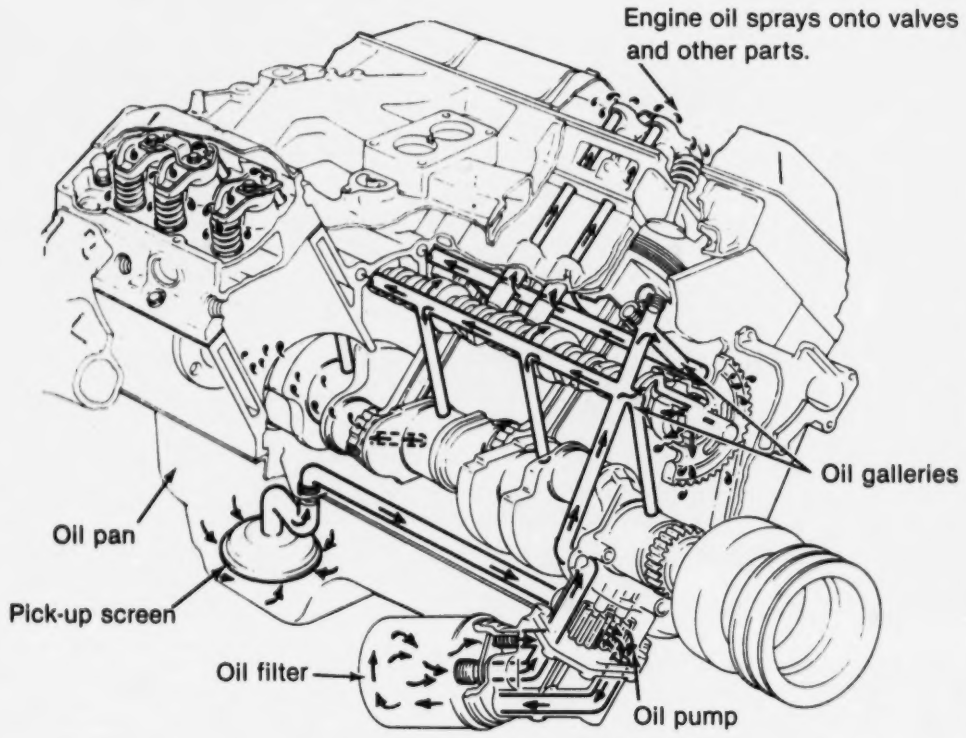
When oil reaches the top of the engine, holes in the upper engine components allow the oil to drain back down into the pan so that it can be circulated through the system again. Figure 2 below shows the movement of oil through one engine design. Service manuals generally provide such illustrations.

FIGURE 2



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SUPPLEMENT 4

Lubricant Additives

Engine oils are modified through the use of chemical additives that help to improve the oil's ability to lubricate, cool, reduce wear and corrosion, and seal engine parts under a variety of operating conditions. Some of the most important additives and their functions are listed below.

Detergents (dispersants) — Hold dirt and other particles suspended in the oil to reduce wear and to carry contaminants to the filter

Viscosity index (VI) improvers — Increase the viscosity rating

Pour-point depressants — Keep multiviscosity oils thin at low temperatures

Extreme-pressure additives — Help oil withstand high pressures so that it is not squeezed completely out of oil clearances between parts

Anti-wear additives — Chemically coat parts to provide wear protection even when oil is squeezed out under high pressures

Oxidation inhibitors — Help prevent the chemical breakdown of oil

Foam inhibitors — Reduce the amount of air that mixes with oil as it circulates through lubrication system

Additives may be mixed with oil for specific purposes. For example, an oil may be high in friction-reducing additives. This type is called *energy conserving*. Oil may be high in additives to prevent breakdown. This type is called *heavy duty* (HD). An oil may be specially formulated with additives for specific applications, such as oils with increased detergents and oxidation inhibitors for use in turbocharged engines. Commercially produced treatments are available for adding to oil in the engine. A service technician should add such treatments only for a specific purpose and then only if the additives are approved by the vehicle manufacturer.

Additives are used in other types of lubricants to give them specific properties for various applications. For example, grease may be compounded for specific uses. Some of the more common special lubricants and their properties are listed below.

Brake grease — Designed to withstand high temperatures and pressures; resistant to water

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Chassis grease — Designed for pressure applications through fittings; resist separation and remain in place well

Extended-lubrication-interval (ELI) grease — Designed for use in permanent and semipermanent applications; hold up well without breaking down; contain special wear and corrosion inhibitors

Extreme- or high-pressure grease — Designed for heavy-load uses, such as some wheel-bearing applications; contain additives that help the lubricant cling to the lubricated surfaces so that a thin layer of lubricant remains on those surfaces even under high pressures

Universal-joint grease — Designed to withstand the turning and flexing of universal-joint parts

Wheel-bearing grease — Designed to stay in place on wheel bearings despite high temperatures and the turning of the bearings

Some greases are known as *multipurpose*. These have some additives that make them suitable for a variety of applications. However, such greases may not have the additives required for a specific application. For example, a multipurpose lubricant may be usable for the wheel bearings of a trailer or a vehicle with drum brakes, but not suitable for the higher temperatures produced by disc brakes. Refer to grease-container directions and vehicle-manufacturer's specifications to make sure that a lubricant is suitable. Some greases are sold for very specific applications such as lubricating speedometer cables. Although these are generally suitable for their specified purpose, they may be more expensive than other lubricants that are also permitted for use by the vehicle manufacturer.

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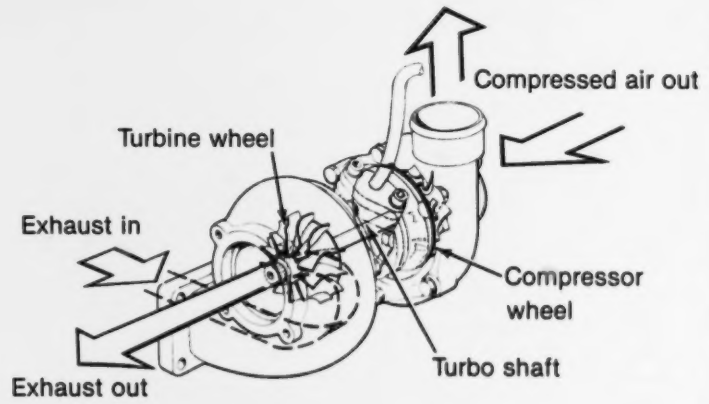
SUPPLEMENT 5

Supercharging

Superchargers have been used on vehicles for many years. In early designs superchargers were normally driven by belts, gears, or chains powered by the engine. The disadvantage of this design is that it takes so much of the engine's power to drive the supercharger that it is only efficient on large engines. Today such superchargers are generally used only on trucks and some racing engines.

However, one form of supercharging is useful in helping to boost the power of small engines. This method uses a supercharger of the centrifugal design. But rather than using belts or other mechanical devices to drive the compressor, this design uses exhaust gases to turn a *turbine wheel*. See Figure 1 below. A turbine wheel is simply a wheel with fins on it. A force—in this case, hot exhaust gases—applied to the fins causes the wheel to turn. The turbine wheel is connected by a shaft to the compressor wheel. The turning compressor wheel forces air into the carburetor or past the fuel injectors. This design is more correctly called an *exhaust-driven turbine supercharger*, but is commonly referred to as a *turbocharger*. Turbochargers do not use up horsepower the way other supercharger designs do and are, thus, suitable for use on small engines.

FIGURE 1



Exhaust-driven turbine supercharger

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However, turbochargers are not without their drawbacks. One problem is that the turbocharger creates a restriction in the exhaust system. Although this is helpful in that it quiets exhaust noises and allows the use of a smaller muffler, it also creates backpressure to the exhaust valves. This robs some of the power added by the turbocharger. The buildup of pressure can even be dangerous. For this reason, turbochargers are equipped with a *wastegate*. A wastegate is a pressure-relief valve that helps keep pressure driving the turbine at a safe, steady level.

Another problem found in turbocharger operation is that air heats up as it is compressed. Warm air has less oxygen, and oxygen is required for proper combustion. To get around this problem, some turbochargers are equipped with an *intercooler*. An intercooler works like a radiator to cool compressed air.

Yet another problem with turbochargers is *turbo lag*: the sluggishness of the engine that occurs at low engine speeds. For a turbocharger to work well, exhaust gases must be forced rapidly through the system. This only occurs at higher engine speeds.

One of the most serious concerns in turbocharger operation is the need for a good supply of clean, high-quality oil. Turbochargers are normally lubricated by the engine lubrication system. During normal operation, the turbocharger shaft may turn at speeds well over 100,000 revolutions per minute. At such speeds, a good oil supply is essential to reduce heat and wear. These speeds also break down oil more quickly and multiply the effects of dirt particles or other contaminants. Generally, vehicle manufacturers specify more frequent oil changes for turbocharged engines. Just as the driver of a turbocharged vehicle must observe certain precautions in the warmup and cooldown of turbos, so must the service specialist make sure that service procedures do not interfere with the operation of the turbocharger.

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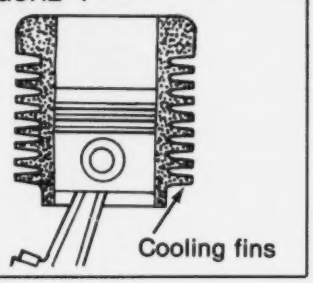
SUPPLEMENT 6

Engine Cooling

Engine operation produces a lot of heat. Heat occurs due to the combustion of the air/fuel mixture and because of movement of parts in contact with each other. There must be some way to remove heat or the engine would eventually melt, break down, or quit running. For this reason, engines are equipped with a cooling system. Automotive engines generally have one of two types of cooling systems—either air or water is used to cool the engine.

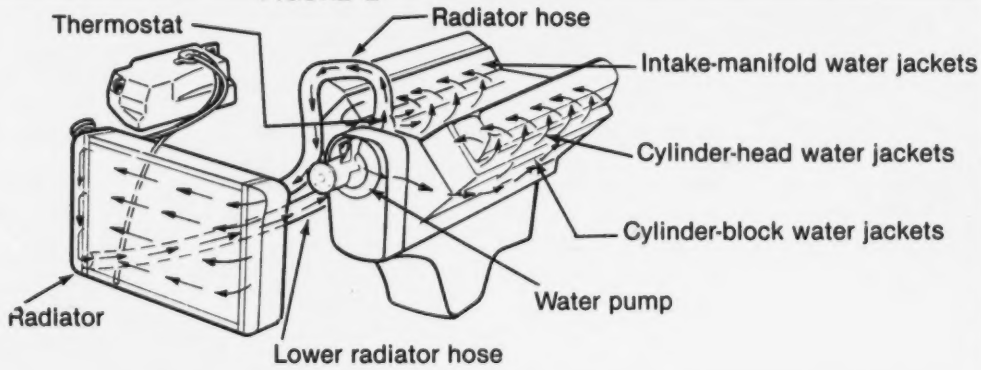
FIGURE 1



Air-cooled engines are designed so that air is forced around the engine parts by fans, by the movement of the vehicle, or both. Air-cooled engines generally have metal fins built into the outside design of the engine (see Figure 1). Heat from the running engine moves throughout the engine metal and the passing air helps to remove the heat, thus cooling the engine.

The water-cooled design is a more common way of cooling automotive engines. Actually, the liquid that is used to cool the engine is a mixture of water and antifreeze (coolant). The mixture is moved through the system by a water pump. Coolant circulates through the radiator, connecting hoses, and chambers in the engine block and head called the *water jacket*. The mixture helps to remove heat that builds up in the engine and carry it away. Most service manuals show the path of circulation for coolant through the cooling system, as in Figure 2 below.

FIGURE 2



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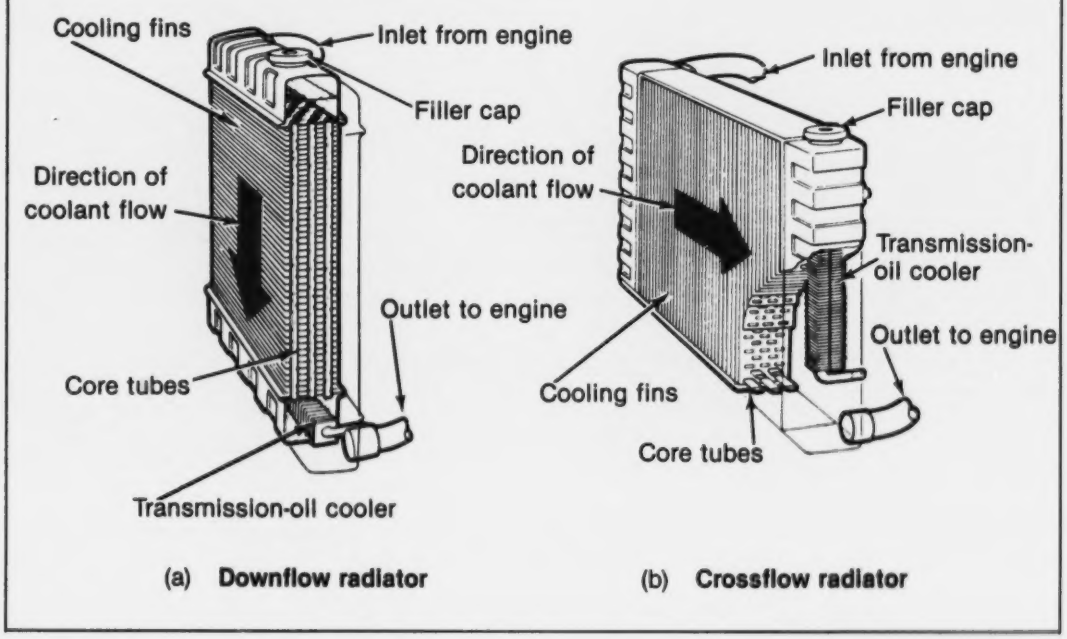
Coolant travels through the radiator. The *radiator* is so named because it radiates heat that has gathered in the coolant, thus reducing the temperature of the coolant mixture. The radiator is simply a series of chambers through which coolant flows. Air is forced around the chambers by a fan or the movement of the vehicle. This cools the water and antifreeze mixture that is in the radiator before it continues on through the system. Radiators are usually of one or two general designs. In one design, called the *downflow-type*, coolant enters the top of the radiator and exits out the bottom. Coolant enters and exits the sides of the radiator in the other design, called the *crossflow-type*. See the illustrations (a) and (b) in Figure 3 below.

FIGURE 3



(a) **Downflow radiator** (b) **Crossflow radiator**

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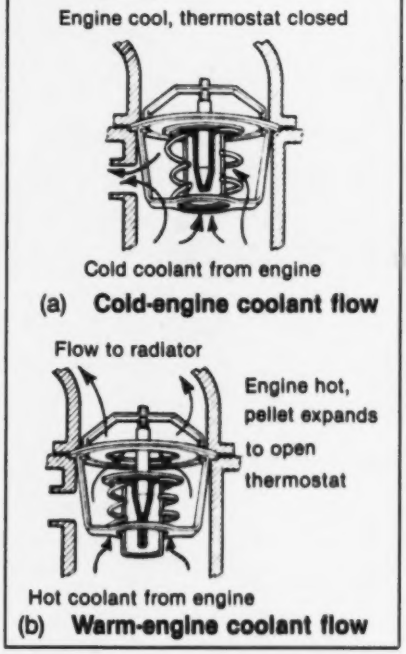
Other components of the cooling system help control the temperature and the amount of coolant that circulates through the system. For most effectiveness, coolant must be maintained at a fairly high temperature without being allowed to boil. There are several reasons for this. First, a warm engine runs better than a cold one. Second, if coolant is allowed to become too cool, it will crack the metal of the engine by cooling it too quickly. Finally, heat from circulating coolant is used to provide heat for the passenger-compartment heater. For these reasons the cooling system is equipped with a *thermostat*. A thermostat is a device that opens and closes with changes in temperature. The thermostat in the cooling system is generally located on the engine at the end of the

FIGURE 4


Engine cool, thermostat closed
Cold coolant from engine
(a) Cold-engine coolant flow
Flow to radiator
Engine hot, pellet expands to open thermostat
Hot coolant from engine
(b) Warm-engine coolant flow

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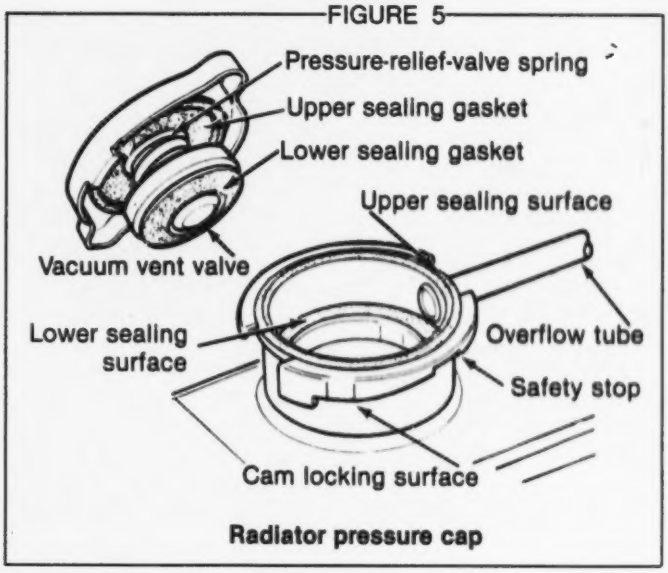
hose that carries coolant from the engine to the radiator. When the engine is cold, the thermostat is closed, thus preventing coolant from flowing to the radiator. See Figure 4 (a). Instead, coolant circulates internally in the engine. As coolant heats up, the thermostat opens, allowing coolant to flow to the radiator. See Figure 4 (b). Because the thermostat can be designed to open and close at fairly accurate temperatures, the temperature of the coolant can be regulated. Most thermostats are rated by the temperature at which they begin to open. Most modern vehicles use thermostats with a rating of between 180°F and 195°F (82°C and 91°C). This allows water circulation at a given temperature, which helps maintain a minimum engine temperature.

FIGURE 5



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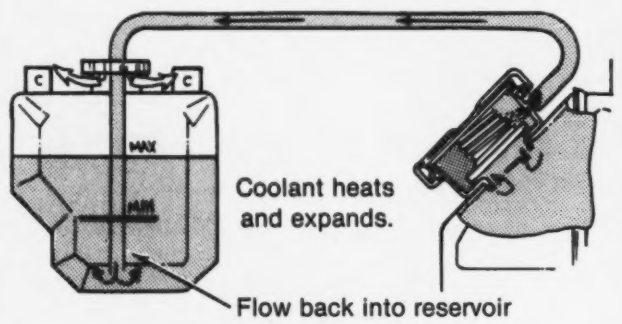
Another important component of the cooling system is the radiator pressure cap. See Figure 5. The cap seals the radiator opening to prevent leaks, but it also contains two valves that are used to control pressures in the cooling system. Water and coolant expand as they are heated. As they expand, pressure in the cooling system builds up. This is both good and bad. It is good because water under pressure will not boil as quickly as water at normal air pressure. Normally, water boils at 212°F (100°C). However, for every pound per square inch (psi) that pressure increases, another 3°F is required to

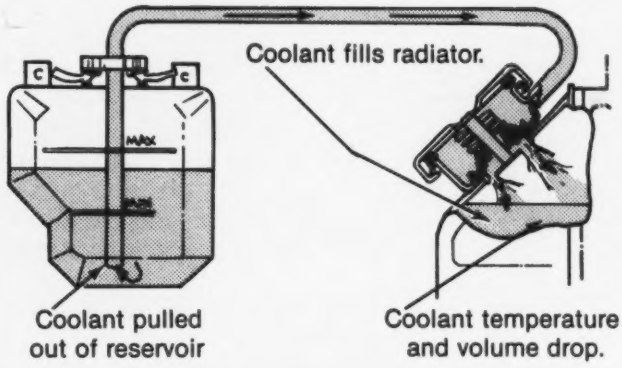
make water boil. Most radiator caps allow pressure to build up to between 12 psi and 16 psi, meaning that coolant will heat another 36°F to 48°F before boiling. This additional heating is helpful because engine surfaces that form the water jacket can heat beyond the unpressurized boiling point.

Although the radiator cap allows pressure to build up some, it is equipped with a relief valve to prevent pressure from becoming too high. If pressure continued to build up, it would eventually damage the cooling system by bursting hoses or splitting open other components. The relief valve allows some of the expanding coolant to escape from the system when the pressure reaches the relief setting. In old designs, excess coolant simply flowed out onto the ground, but modern vehicles are equipped with coolant-recovery systems.

FIGURE 6



(a) **Warm-engine coolant flow**



(b) **Cold-engine coolant flow**

The coolant-recovery system consists of a second valve in the radiator cap and a hose running from the radiator-cap neck to a tank. As pressure builds up when the engine is warm from running (see Figure 6 [a]), the radiator-cap relief valve opens, permitting coolant to flow into the recovery tank. When the engine is shut off and the cooling system cools down (see Figure 6 [b]), the radiator-cap vacuum valve opens. Air pressure forces coolant from the reservoir back into the radiator to maintain the proper level of coolant in the system.

Parts of the cooling system may be used to cool vehicle components other than the engine. For example, many vehicles with automatic transmissions have systems that circulate transmission fluid through a chamber in the radiator or beside the radiator to benefit from the airflow of the fan.

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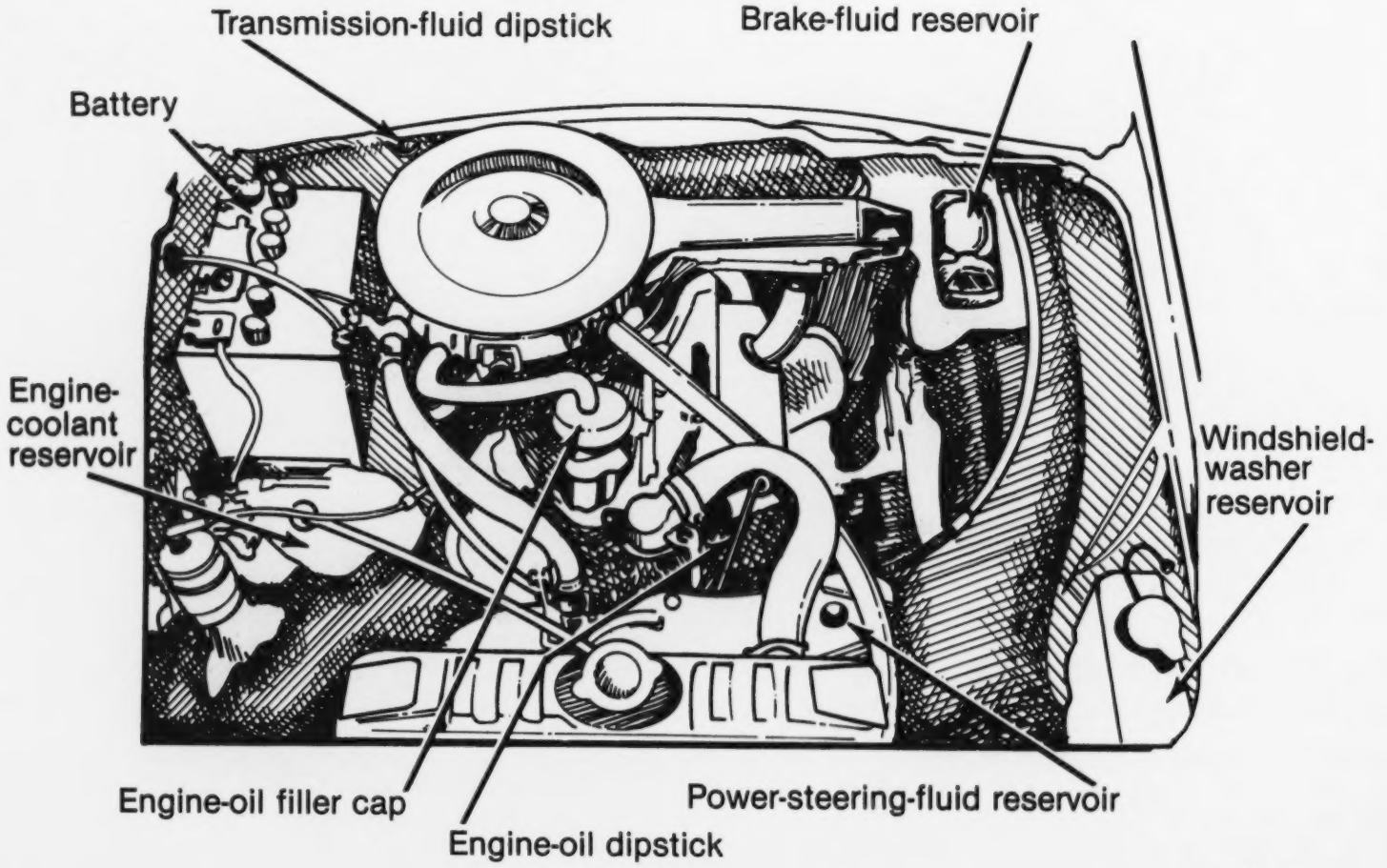
Fluid Systems



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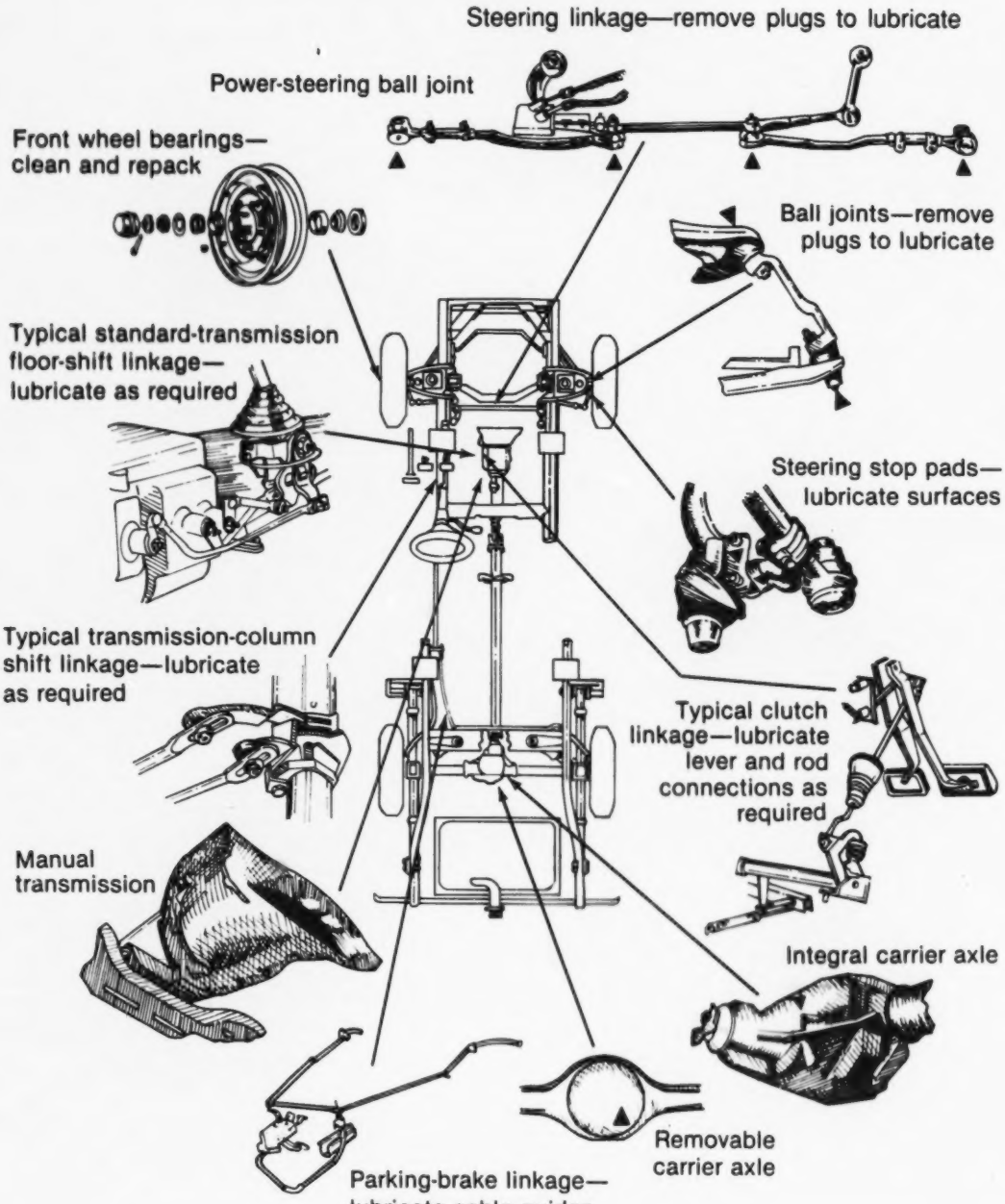
TM 1

Lubrication Points


Steering linkage—remove plugs to lubricate
Power-steering ball joint
Front wheel bearings—clean and repack
Ball joints—remove plugs to lubricate
Typical standard-transmission floor-shift linkage—lubricate as required
Steering stop pads—lubricate surfaces
Typical transmission-column shift linkage—lubricate as required
Typical clutch linkage—lubricate lever and rod connections as required
Manual transmission
Integral carrier axle
Removable carrier axle
Parking-brake linkage—lubricate cable guides, levers, and linkage as required

▲ Lubrication point

1120

Oil-Can Markings

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Oil-Bottle Markings

PENNZOIL
HD
SAE 30 MOTOR OIL WITH Z-7®
WORLD CLASS PROTECTION™
This heavy duty (HD), single weight motor oil is formulated with additive Z-7 and high performance, high VI, base stocks. It provides maximum protection against thermal breakdown, engine deposits and wear. It is recommended for vehicles fueled with gasoline, diesel, or LPG.
This world class formulation exceeds demanding European standards (CCMC, Daimler-Benz 226.0).
Exceeds all U.S. warranty requirements for gasoline, diesel, and turbocharged engines, including Ford ESE-M2C-153D, and GM 6085M, when SAE 30 is recommended. Surpasses the American Petroleum Institute's (API) highest automotive standards for high temperature protection (API SG, SF, SF/CC, SF/CD, SG/CD). Turbo approved.
0 71611 93539 5
API Service SG,SF/CC,CD
CAUTION: Avoid contact with used motor oil. Prolonged contact with used motor oil has caused skin cancer in laboratory animals. Wash skin thoroughly with soap and water after contact.
DON'T POLLUTE. CONSERVE RESOURCES. RETURN USED OIL TO COLLECTION CENTER.
Patented™
PENNZOIL PRODUCTS COMPANY
Oil City, PA 16301 USA
API SERVICE SG, SF/CC,CD
SAE 30

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Antifreeze Protection Chart

ETHYLENE GLYCOL TYPE

"PRESTONE" · "ZEREX" · "PEAK"

FLOAT READING	THERMOMETER READING °F.													FLOAT READING
	60	70	80	90	100	110	120	130	140	150	160	170	180	
	FREEZING POINT °F.													
N	32	32	32	32	31	30	28	27	25	23	21	19	17	N
O	29	28	27	26	25	24	23	21	19	17	15	12	1	O
P	24	23	22	21	19	18	16	14	11	8	5	2	2	P
Q	19	18	17	15	14	12	10	7	4	1	3	8	13	Q
R	15	14	12	10	8	6	3	0	4	8	12	18	25	R
S	12	10	8	6	4	1	2	6	10	15	20	28	30	S
T	8	6	4	2	1	5	8	12	18	24	30	39		T
U	4	1	1	4	7	11	15	20	26	34	42			U
V	1	3	5	8	12	17	21	27	34	43				V
W	4	7	10	14	18	23	28	35	44					W
X	8	12	16	20	25	30	37	45						X
Y	13	17	21	26	32	38	46							Y
Z	19	23	28	33	40	48								Z

ABOVE-ZERO ZONE

BELOW-ZERO ZONE

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1123

PRETEST ANSWERS

MAINTAIN FLUIDS AND LUBRICANTS

EVALUATOR NOTE

Use the answer key on the next page to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 19, 31
2	2, 3, 20, 21
3	13, 14, 27
4	16, 17, 28
5	4, 22, 32, 33
6	11, 12, 24, 34
7	25, 26
8	5, 23
9	6, 7, 8, 9, 10, 33
10	15, 29, 35
11	18, 30

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ANSWER KEY

1. c
2. b
3. d
4. a
5. a
6. c
7. b
8. c
9. b
10. c
11. c
12. c
13. d
14. a
15. d
16. a
17. b
18. d
19. a
20. d
21. a
22. d
23. b
24. a
25. d
26. d
27. c
28. b
29. b
30. b
31. a
32. a
33. d
34. c
35. a

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PRETEST

MAINTAIN FLUIDS AND LUBRICANTS

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. The best definition for a *fluid* is

   a. A source of leaks in an automotive system
   b. A type of lubricant found in transmissions and gearboxes
   c. A substance that flows
   d. A substance that resists frictional heat buildup

2. Which of the following is **not** usually considered an automotive lubricant?

   a. Engine oil
   b. Gasoline
   c. Gear oil
   d. Graphite

3. Which of the automotive fluids listed below is normally petroleum-based?

   a. Windshield-washer solvent
   b. Brake fluid
   c. Antifreeze
   d. Automatic-transmission fluid

4. Which of the engine-oil viscosities listed below is best suited for high-speed driving during the summer in Florida?

   a. SAE 40
   b. SAE 30
   c. SAE 20
   d. SAE 10

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5. Which of the following automotive fluids usually contains a red dye?

   a. Automatic-transmission fluid
   b. Brake fluid
   c. Antifreeze
   d. Windshield-washer solvent

NOTE: Use the following chart to answer questions 6 through 10.

USAGE	FLUID/LUBRICANT
Engine Oil	GM Goodwrench Motor Oil or equivalent for API service, SF/CC or SF/CD of the recommended viscosity.
Engine Coolant	Mixture of water and good quality ethylene glycol base antifreeze conforming to GM spec. 1825M (GM Part No. 1052753)
Brake and Hydraulic Clutch Systems	Delco Supreme 11 Fluid (GM Part No. 1052535) or DOT-3 Fluid
Parking Brake Cables	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Power Steering System	GM power steering ifuid, Part No. 1050017 or equivalent.
Manual Steering Gear (recirculating ball)	Use lubricant meeting requirements of GM-4673-M (GM Part No. 1052182)
Automatic Transmission/Transaxle and 5 speed Manual Transmissions	DEXRON®-II Automatic Transmission Fluid (GM Part No. 1051855)
Manual Transaxle	SAE 5W-30 (GM Part No. 1052931) Manual Transaxle Fluid
Manual Transmission (rear-wheel-drive) 3 and 4 speed	Corvette overdrive unit and Pontiac Firebird 4 speed manual — DEXRON®-II. All others SAE-80W gear lubricant (GM Part No. 1052271)
Manual Transmission/Transaxle Shift Linkage	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Key Lock Cylinders	Light oil or general purpose silicone lubricant (GM Part No. 1052276)
Automatic Transmission/Transaxle Shift Linkage	Engine Oil
Clutch Linkage Pivot Points	Engine Oil
Floor Shift Linkage	Engine Oil
Power Antenna Mast	Light Oil (GM Part No. 1052949)
Chassis Lubrication	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Standard Differential Rear Axle	SAE 80W or SAE 80W-90 GL-5 (SAE 80W GL-5 in Canada) gear lubricant (GM Part No. 1052271).
Limited-Slip Differential Rear Axle	Some models require a special gear lubricant additive in addition to (GM Part No. 1052271)*
Windshield Washer Solvent	GM Optikleen Washer Solvent (GM Part No. 1051515) or equivalent

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6. Which of the following lubricants should be used in a five-speed manual transaxle?

   a. SAE 5W-30 manual transaxle fluid
   b. SAE 80W gear lubricant
   c. DEXRON II ATF
   d. SAE 80W-90 GL5 gear lubricant

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7. Antifreeze for this series of vehicles contains which of the following bases?

   a. Ethylene silicone
   b. Ethylene glycol
   c. Glycol glycerine
   d. Water

8. Brake fluid for this series of vehicles must have a minimum DOT rating of

   a. 1
   b. 2
   c. 3
   d. 4

9. What transmission fluid should be used in a Buick Regal covered by this chart if the car has a four-speed manual transmission?

   a. DEXRON ATF
   b. SAE-80W gear lubricant
   c. DEXRON II ATF
   d. SAE-80W-90 GL-5 gear lubricant

10. Which engine-oil service rating listed below could be used in vehicles of this series?

    a. SE/CC
    b. SE/CD
    c. SF/CC
    d. SF/CB

11. Technicians A and B are discussing factors that affect the usable life of engine oil. Technician A says that pulling heavy loads, driving in the mountains, and driving where it is dusty will require more frequent oil changes. Technician B says that driving where it is very wet or driving mostly on short trips will require oil changes more often than the normal interval.

    Who is correct?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

1193

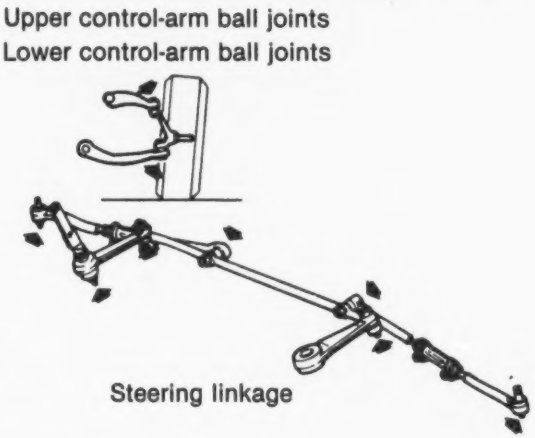
12. Which of the following steps is **not** normally performed during an oil change and filter replacement?

    a. The drain plug is cleaned and its threads are inspected
    b. Clean oil is applied to the oil filter gasket before it is installed
    c. The oil filter is torqued to specifications with an oil-filter wrench
    d. The engine is started and idled to check for proper oil pressure and for leaks

13. Which of the following is **not** one of the normal methods for lubricating steering and suspension parts?

    a. Surface application
    b. Pressure application
    c. Packing
    d. Submersion application

14. Refer to the following diagram, and determine how many points require lubrication during normal steering and suspension service?



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    a. 11
    b. 10
    c. 9
    d. 8

1129

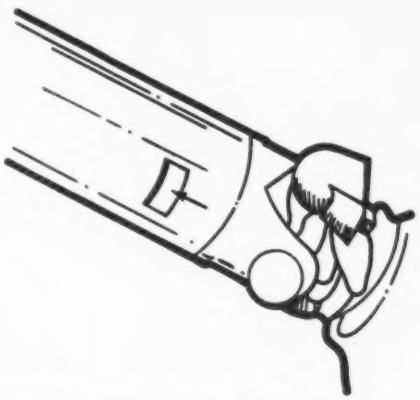
15. Technicians A and B are discussing fluid levels. Technician A says that fluid should always be maintained below the manufacturer's full level specification because fluids expand as they are heated during use. Technician B says that fluids should always be maintained slightly above the full level specification to make up for losses due to leaks and worn parts.

Who is right?

a. Technician A
b. Technician B
c. Technician A for new vehicles and Technician B for high-mileage vehicles
d. Neither A nor B

16. The object indicated by an arrow in the illustration is

a. A drive-shaft balance weight
b. A drive-shaft identification label
c. A drive-shaft lubrication fitting
d. A drive-shaft lubrication drain plug



17. Technicians A and B are discussing driveline lubrication requirements. Technician A says that most factory-original U-joints require periodic lubrication and that one should refer to the service manual to see how often lubrication is required. Technician B says that generally only replacement U-joints require lubrication, but one should check the service manual to be sure.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

1139

18. Which of the following is **not** a procedure that can be used to clean cooling-system components such as the radiator or engine water jacket?

    a. Chemical flushing
    b. Fast flushing
    c. Reverse flushing
    d. Boiling

19. An *inhibitor* is

    a. A chemical added to a fluid or lubricant to prevent some action from taking place
    b. A signal, usually a light located on the instrument panel, that indicates low fluid levels through pressure or temperature readings
    c. A device installed in a fluid system to inhibit the formation of rust or corrosion
    d. A chemical that breaks down other substances, such as fluid- and lubricant-system components

20. The lubricant normally used on bearings and ball joints is

    a. Engine oil
    b. Gear oil
    c. Silicone
    d. Grease

21. Technicians A and B are discussing fluid requirements for power-steering systems. Technician A says that ATF can be used in some power-steering systems but that others require special fluids designed just for power-steering systems. Technician B thinks that power-steering fluids are a rip-off and says that automatic-transmission fluid can be used in power-steering systems as long as the technician uses the same type of ATF as is specified for the transmission.

    Who is right?

    a. Technician A
    b. Technician B
    c. Technician A for vehicles manufactured before 1986 and Technician B for vehicles manufactured after 1986
    d. Neither A nor B

1131

22. API service ratings indicate an engine oil's suitability for certain kinds of engines under various conditions based primarily on

    a. The oil's viscosity
    b. Whether the oil is synthetic or petroleum-based
    c. The time between oil changes for that vehicle
    d. The refinement process, including the make-up of chemical additives

23. One of the main considerations in selecting a type of antifreeze is

    a. How cold it gets in the area where the vehicle will be used
    b. The suitability of the antifreeze's corrosion inhibitors with the metals used in the engine
    c. Whether the antifreeze will be mixed with water or used straight
    d. Whether the antifreeze contains emulsified oils, especially for older vehicles

24. Engine oil should be changed when the oil is at

    a. Normal operating temperature to make it flow more easily and to make sure dirt and contaminants are suspended in the oil
    b. Room temperature after at least a 30-minute cool-down period to prevent injuries due to hot oil and to make sure all oil has drained into the oil pan
    c. Normal operating temperature and the engine running so that all dirty oil can be pumped from the system
    d. Any temperature that is convenient for the service person

25. Technicians A and B are discussing lubrication of turbocharged engines. Technician A says that turbocharged engines require less frequent oil changes than normal engines because they run so much more efficiently. Technician B says that turbocharged engines require less frequent oil changes because they run colder than normal engines.

    Who is right?

    a. Technician A
    b. Technician B
    c. Both A and B
    d. Neither A nor B

1132

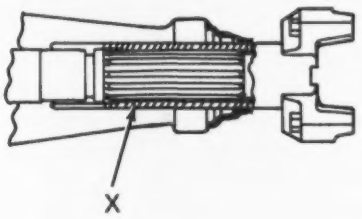
26. To ensure that a turbocharger is properly lubricated after an oil change, the engine should be

    a. Raced for approximately one-half minute to ensure full oil flow as specified by the vehicle manufacturer
    b. Allowed to idle at a low engine speed for 5 to 10 minutes before driving, as specified by the vehicle manufacturer
    c. Started and stopped immediately for several times as specified by the vehicle manufacturer until normal oil pressure is reached
    d. Cranked with the ignition system disabled as specified by the manufacturer until specified oil pressure is reached

27. Dust boots frequently cover parts of the steering and suspension systems that require lubrication. Proper service of dust boots includes

    a. Replacement any time the steering or suspension system needs lubrication
    b. Inspection for cracks or splits whenever the steering or suspension systems are lubricated and replacement if required
    c. Inspection for damage and positioning during under-vehicle service and replacement if required
    d. No service is required for dust boots

28. Part X shown below is called a



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    a. Splined rotor shaft
    b. Slip-joint
    c. Split drive shaft
    d. Transfer case

1133

29. Some gearboxes are not equipped with drain holes. In order to drain such gearboxes, the normal procedure is to

    a. Raise the vehicle enough to allow drainage from the fill hole
    b. Use suction, such as from a hand pump, to remove fluid through the fill hole
    c. Disassemble the case housing
    d. Leave the fluid in place because gearboxes without drain holes do not require draining

30. The cooling system should be flushed

    a. Every 12,000 miles or one year, whichever comes first
    b. Whenever there are indications of rust or scale buildup in the cooling system
    c. Prior to removal of the radiator for service
    d. Any time the coolant is changed

31. A *lubricant* is

    a. A substance used to help parts in contact move more easily
    b. A substance used to keep vehicle parts dry
    c. A device used to move fluids through a system
    d. A device used for adding fluid to a system

32. The measure indicating an oil's thickness in comparison to other oils when heated is called its

    a. Viscosity rating
    b. Pourability specification
    c. Service rating
    d. Grade recommendation

33. If a vehicle manufacturer specifies an API service rating of SD, which of the following service ratings **cannot** be used in the vehicle?

    a. SF
    b. SE
    c. SD
    d. SC

1134

34. Technicians A and B are discussing oil-change intervals for a vehicle with a recommended oil-change interval of 3000 miles or 3 months. Technician A says that if the vehicle is used to pull a trailer on a trip to the mountains, then the oil should be changed before the full time or mileage interval is reached. Technician B says that if the vehicle is driven only 2500 miles in 3 months, the oil should still be changed.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

35. Which of the following is **not** a guideline that must be practiced when working with fluids?

a. Mix fluids of different types and ratings thoroughly to ensure that the mixture is uniform
b. Follow all requirements for the handling and storage of fluids that are flammable or toxic
c. Dispose of fluids properly
d. Do not allow fluids, especially brake fluids, to contact painted surfaces

1135

INFORMATION SHEET

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 1

Recognize definitions of terms associated with maintaining fluids and lubricants

Fluid — Substance that flows

Lubricant — Substance used to help parts in contact move more easily

Filter — Device used to remove foreign materials from substance moving through it

EXAMPLES: Engine-oil filter, fuel filter, air cleaner

Turbocharger — Device used to increase engine power by forcing more air/fuel mixture into combustion chamber

Viscosity — Measure of how easily a liquid flows

Inhibitor — Chemical added to fluid or lubricant to prevent some action from taking place

EXAMPLES: Rust or corrosion inhibitor, foam inhibitor

MPO — Abbreviation for *multipurpose gear oil*, a lubricant used in transmissions, differentials, and other gearboxes

Sustained — Continued for a long time

EXAMPLE: Sustained driving at high speeds

Acid — Chemical that breaks down other substances

Fluids and Lubricants

You may have noticed a spot or a puddle of liquid on a driveway or parking lot after a vehicle drives away. This is a sign that the vehicle has a leak in one of the many systems that contain fluids or lubricants. Many automotive systems contain liquids that cool parts, protect them from wear or physical damage, move power from one point to another, or perform other functions. Because such a wide use is made of fluids and lubricants, which are often under high pressure, leaks are fairly common. The service specialist is something of a detective when it comes to determining what is leaking and where it is coming from. By examining the liquid, you can figure out which fluid or lubricant is leaking. This will probably give you some idea of the system that is the source of the leak. A leak may also be a clue to a performance problem, such as engine overheating or hard shifting in an automatic transmission. As you study about fluids and lubricants, pay attention to the characteristics of those substances and their uses so that you will be able to read the clues in leaks and performance problems.

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OBJECTIVE 2

Recognize the nature and purpose of automotive fluids and lubricants

NOTE: The primary function of a lubricant is to reduce friction between moving parts. Fluids, on the other hand, have other functions, such as transmitting hydraulic power. But fluids also lubricate. For example, a power-steering pump is lubricated by power-steering fluid and a water pump is lubricated by coolant.

Lubricants

- Engine oil — Petroleum-based or synthetic liquid designed to reduce wear of engine parts
- Gear oil — Petroleum-based liquid that is generally heavier than engine oil; used in gearboxes such as manual transmissions and differentials

  NOTE: Sometimes engine oil is used in gearboxes. Also, some specially designed differentials, known as *limited-slip differentials*, require specific gear lubricants. As with all lubricants, follow the vehicle manufacturer's recommendations.
- Grease — Thick lubricant made from petroleum and a mixture of fatty acids and soft metals, such as calcium or lead; used on bearings and joints
- Graphite — Soft carbon powder, sometimes mixed with grease or oil; used to lubricate door and trunk lock mechanisms and some electrical components, such as starter motors

Friction

Friction is the resistance to movement of two surfaces in contact with each other. The resistance may be great or small. For example, shoes may have rubber or leather soles. Rubber soles are usually less likely to slip because they offer more resistance to movement and may have special designs to increase friction. Friction is sometimes useful in footwear. However, friction can be bad. Engine parts, gears, and other components produce friction as they move against each other. This friction leads to wear. It also produces heat, just as rubbing your hands together warms them. Friction can be reduced by lowering the resistance to movement. One method of reducing friction is the use of lubricants such as grease and oil. Lubricants not only reduce friction but they also help cool the parts and cushion the impact between parts.

- Silicone — Dry lubricant used on rubber and plastic parts, such as weatherstripping
- Wax — Soft, solid substance such as paraffin used on door latches and striker posts

  EXAMPLE: Door-Eze

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Fluids

- Automatic-transmission fluid (ATF) — Petroleum-based oil used to transmit hydraulic power

  NOTE: ATF comes in three common types: Dexron II, Type F, and Type H. Each has special properties. Be sure to use the type recommended by the vehicle manufacturer. Also, ATF is used for some power-steering systems and standard gearboxes.

- Brake fluid — Nonpetroleum fluid used for brake systems and some clutch systems for manual transmissions

- Antifreeze — Alcohol-based (usually ethylene glycol) liquid mixed with water to provide better cooling, reduce rust and corrosion, and prevent freezing of coolant

- Power-steering fluid — Petroleum-based oil formulated to allow quicker response to pressure changes than most ATFs provide

One step more . . .

Fluid and Lubricant Labels

It is important that the automotive service specialist be able to understand the information on the labels of products used to service vehicles. Such labels provide information about the uses of the products, precautions concerning their use, information about special contents in the products, and classification information about the product. Automotive fluids and lubricants provide good examples of information on labels. Try to find examples of the fluids and lubricants listed with this objective in your shop. If possible, get examples of each type from various manufacturers. Then study the labels. Compare labels from different products and different manufacturers. What is common to each? What is different? What instructions for use are given? What precautions? Does the label contain special codes such as ratings? What information given in this objective is also contained on the labels?

1133

OBJECTIVE 5

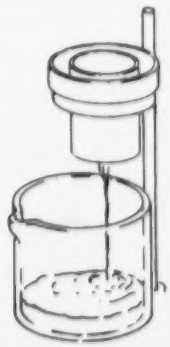
Explain the meaning of engine-oil ratings

NOTE: Two types of ratings are given to engine oils: viscosity ratings and service ratings. Viscosity ratings are discussed on this page, while service ratings are discussed on the next page.

Viscosity rating

- Indicates oil's thickness when heated in comparison to other oils
- Represented by a number
- The higher the number, the thicker the oil remains at high temperatures

Viscosity



Viscosity is the ease with which a liquid pours. For example, water pours fairly easily, while cold molasses is very thick and pours slowly. The Society of Automotive Engineers (SAE) rates engine-oil viscosity. To test an oil's viscosity, a specific amount of oil at a given temperature is poured into a container with a hole in the bottom. The time required for the oil to flow through the hole is checked, and the oil is rated. The viscosity rating, or weight, is a number such as SAE 10, SAE 20, or SAE 50. The higher the number, the thicker the oil remains at engine operating temperatures. Thick oil is good in that it can withstand high temperatures and provide excellent lubrication. However, just like molasses, engine oil becomes more viscous at low temperatures. Thus, although a 50-weight oil may be desirable for a car operating in a hot desert, it would be wrong for a car driven in Minnesota during January. The oil would become too thick, which would probably mean the starter could not crank the engine. For this reason, oil manufacturers chemically change some oil to produce multigrade engine oil. Multigrade oils act like thin oils when they are cold and like thick oils as they warm up. For example, SAE 10W-40 has the viscosity of an SAE 10W oil when it is cold, as indicated by the *W*, which stands for *winter*. However, at high operating temperature, the oil acts like an SAE 40 oil. In selecting an oil, you should use the viscosity recommended by the vehicle manufacturer.

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Service rating

- Indicates oil's suitability for use in certain types of engines and the amount of chemical modification that was done to the oil when it was refined
- Represented by two letters; the first letter refers to the engine type, while the second letter shows the level of chemical modification
- The farther from *A* that the second letter is in the alphabet, the more the oil has been chemically modified; oils of higher ratings (letters farther from *A*) than that specified by the vehicle manufacturer can be used but oils with lower ratings (letters closer to *A*) cannot be used

API Service Ratings

The American Petroleum Institute (API) gives service ratings to engine oils. The ratings are given in two-letter codes, beginning with either a *C* or an *S*. The *C* indicates oils intended for use in compression-ignition engines, such as diesel engines. The *S* designates oils intended for use in spark-ignition engines. However, some oils have both *S* and *C* ratings.

The second letter of the rating code identifies the service for which the oil is intended. Basically, service ratings for oil are determined by the additives in the oil. *Additives* are chemicals that give the oil certain improved properties. For example, detergent additives help clean engine parts while other additives guard against rust and corrosion.

The letters *C* through *F* have been used as the second code letter to identify oils with the proper additives to meet vehicle manufacturer's warranty requirements. Every few years, the warranty requirements change, and therefore, the letter designations change. For example, SC-rated oil met the 1964 warranty requirements. It was replaced in 1968 by SD-rated oil. SF-rated oil was approved in 1980, and SG will be the next oil designation.

Follow the vehicle manufacturer's recommendations when selecting engine oil. And remember, you can use a higher grade oil than recommended, but never use a lower grade.

1140

OBJECTIVE 8

Recognize how automotive fluids are identified

NOTE: Fluids often contain additives similar to those used in engine oil. Anticorrosion, foam-inhibiting, friction-modifying, and viscosity-improving additives are the most common.

Automatic-transmission fluid — Label carries a manufacturer's code that designates fluid's specific viscosity to work best with the materials and openings in a particular transmission/transaxle design; fluid contains a red dye to distinguish it from other fluids

NOTE: Remember that the different types of transmission fluids cannot be substituted for one another. Follow the vehicle manufacturer's recommendations.

Brake fluid — Label carries a Department of Transportation (DOT) numerical rating

NOTE: Most vehicles require a DOT 3 or higher rating. Check the vehicle manufacturer's recommendations. Also be sure that the type of brake fluid to be added—silicone or glycol—is the same as that already in the system. If it is not, completely replace the fluid.

Antifreeze — Label gives mixing instructions for various protection levels and lists restrictions for use of corrosion inhibitors and lubricants with various cooling-system materials

Power-steering fluid — Label lists suitability recommendations that are based on specific flow-control properties for the quick changes in pressure and gear positions required

Corrosion

Corrosion is the damage done to metals by acids. Acids may eat the metal away or cause deposits to form on the metal. Acids, some mild and some very strong, are present in all automotive systems. For example, sulfur is present in gasoline, engine oil, and most petroleum-based products. When sulfur is exposed to water or water vapor, sulfuric acid is formed. Thus, sulfuric acid is present in just about any system or component containing petroleum-based substances, including the engine, fuel system, transmission and gearboxes, and bearings and joints. Acids are also found in various chemicals, in water, in salts, and even in the air. Corrosion inhibitors are used in automotive fluids to help reduce the formation of acids to protect parts.

1141

ASSIGNMENT SHEET 1	MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 9

Interpret fluid and lubricant charts

Name _____ Score _____

INTRODUCTION

Automotive fluids and lubricants have been designed for specific purposes. The fluid or lubricant used in a vehicle must be designed to meet the needs of that particular vehicle. Otherwise, the performance of the vehicle may not be what it should, and damage to the system may occur. A service technician must be able to read the charts in owner's manuals, service manuals, and professional manuals, such as Chilton's, in order to be able to determine the fluid and lubricant requirements for any vehicle and to select fluids and lubricants that meet those requirements.

DIRECTIONS

Below are some situations and questions that require you to select fluids and lubricants for specific purposes. Read the situations and provide the information requested.

1. Use whatever resources are needed to give the correct type of automatic-transmission fluid to be used in the vehicles listed below.

   a. 1987 Dodge Shadow _____

   b. 1986 GMC Suburban _____

   c. 1985 Jeep Cherokee _____

   d. 1984 AMC Eagle _____

   e. 1985 Honda Civic _____

   f. 1986 Volvo 760 GLE _____

   g. 1987 Ford Taurus _____

2. Use whatever resources are needed to give the correct lubricant for use in the transfer case of the vehicles listed below.

   a. 1980 AMC Eagle (Model 119) _____

   b. 1982 AMC Eagle (Model 129) _____

   c. 1986 Chevrolet S-10 Blazer _____

   d. 1985 Nissan four-wheel-drive pickup _____

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3. To answer the following questions, refer to the chart on the opposite page for 1980 Dodge pickups with four-wheel drive (4WD).

   a. What lubricants can be used on the front and rear wheel bearings?

   _____

   b. What lubricant is used in the differential?

   _____

   c. What lubricants can be used on the universal joints?

   _____

   d. Which of the following can be used to replace the original fluid in a vehicle with a four-speed overdrive manual transmission? Place a check by the correct answer(s).

_____ Dexron	_____ MPO 75W
_____ Dexron II	_____ MPO 50W-80
_____ MPO SAE 90	_____ MPO 75W-80
_____ MPO SAE 50	_____ MPO 80W-90

   e. If the vehicle is equipped with a four-speed manual transmission (NP-435) and is being operated where the temperature is normally below freezing, what lubricant should be used in the transmission?

   _____

   f. What brake fluid is required?

   _____

   g. Can SF/CD engine oil be used in this vehicle?

   _____

   h. If the vehicle operates under a light-duty emission cycle, when should the radiator be drained and flushed the first time?

   _____

   i. After the first time the radiator is drained and flushed, how often should this be done?

   _____

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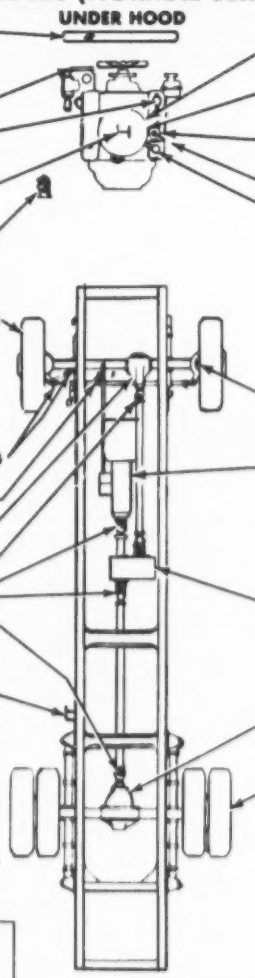
LUBRICATION CHART
W MODELS (NORMAL SERVICE)



Engine Coolant
12/15 Check, service as required — "LDC"
24 Drain flush and refill, then every 12/12 thereafter "LDC"
12/12 Check and service as required — "HDC"
12/12 Drain flush and refill thereafter

Power Steering Pump
DOS Check fluid level

Engine Oil — EO
12/7.5 Change — "LDC"
12/6 Change — "HDC"

Carburetor Choke Shaft — CC
12/7.5 Clean — "LDC" — B
12/30 Clean — "LDC" — A
12/12 Clean — "HDC"

Brake Master Cylinder — BF
DOS Check fluid level

Front Wheel Bearings — MG or MMG
24 Inspect, except with 44F — BJ
15 Inspect with 44F — BJ — "LDC"
12 Inspect with 44F — BJ — "HDC"

Spindle Needle Bearings MG
15 Clean, repack 44F — BJ "LDC"
12 Clean, repack 44F — BJ "HDC"
24 Clean, repack spicer 60F

Drag Link and Tie Rod Ends — MMG
7.5/6 W 15.2 — AW1 Lubricate
6/6 W 2-3-4 Lubricate

Clutch Torque Shaft — MG
22.5/24 Lubricate (1 fitting) — "HDC"
24/24 Lubricate (1 fitting) — "LDC"

Front Axle Differential — MPO
DOS Check for leakage

Universal Joints — MG or MPG
7.5/6 Lubricate — "LDC"
6/6 Lubricate — "HDC"
Lubricate daily if operated in water

Ratio Lever (Park Brake)
22.5 Lubricate

Fuel Filter
30 Replace — "LDC" — B
18 Replace — "HDC"

Carburetor Air Filter
30 Replace element — "LDC"
12 Clean — "HDC"
24 Replace element — "HDC"

Manifold Heat Control Valve —
30 Apply solvent — "LDC" — B
18 Apply solvent — "HDC"

Engine Oil Filter
Replace (with first oil change then every second oil change)

Crankcase Inlet Air Cleaner
30 Inspect and service — "LDC" — B
12/12 Inspect and service — ("HDC")

PCV Valve
15 Check valve — "LDC" — B = Replace 30
12 Check valve — "HDC" Replace 24,000 miles

Front Axle Pivots — MP, MPG
6/6 Lubricate Pivots (with spicer 60F Axle) — "HDC" — 6/7.5 for — "LDC"

Transmission-Manual *
DOS Check oil level
36 Drain and refill — "HDC"
37.5 Drain and refill — "LDC"

Transmission — Automatic
DOS Check fluid level
22.5 Check fluid, filter and adjust — "LDC"
24 Change fluid, filter and adjust — "HDC"

Transfer Case**
DOS Check fluid level
37.5 Drain and refill — "LDC"
36 Drain and refill — "HDC"

Rear Axle Differential — MPO
DOS Check for leakage

Rear Wheel Bearings — MG or MMG
"Semi-Floating" Lubricate when axle shafts are removed
48 "Full-Floating" Lubricate And during Brake Service

* 4-speed overdrive (A-833) initial fill is automatic transmission fluid labeled DEXRON. Multi-Purpose Gear Oil SAE 90, 75W, 75W-80, 80W-90 or 85W-90 may be used.

* NP-435 four speed, — engine oil SAE 50 above 32 or SAE 30 below 32 , Multi-Purpose Gear Oil SAE 80, 90 or 140 may be used, see text.

** NP 208, use Dexron II

** NP 205, use Multi-Purpose Gear Oil meeting API specification GL5 or engine oil for service "SE and CC."

FREQUENCY SYMBOLS

DOS	During Other Services — Check
"LDC"	Light Duty Emission Cycle — Schedule A or B
"HDC"	Heavy Duty Emission Cycle
6/6	6 Months or 6,000 Miles (9 600 km)
6/7.5	6 Months or 7,500 Miles (12 000 km)
12/6	12 Months or 6,000 Miles (9 600 km)
12/7.5	12 Months or 7,500 Miles (12 000 km)
12/12	12 Months or 12,000 Miles (19 000 km)
12/15	12 Months or 15,000 Miles (24 000 km)
12/22.5	12 Months or 22,500 Miles (36 000 km)
24/22.5	2 Years or 22,500 Miles
18	18,000 Miles (29 000 km)
24	24,000 Miles (38 000 km)
30	30,000 Miles (48 000 km)
36	36,000 Miles (58 000 km)
37.5	37,500 Miles (60 000 km)
48	48,000 Miles (77 000 km)

KEY TO LUBRICANTS

ATF	DEXRON II Type Automatic Transmission Fluid
CC	Carburetor Cleaner
EO	Engine Oil (SE CC)
BF	Brake Fluid, Hi-Temp. — DOT 3
MG	Multi-Purpose Grease, NLGI grade 2 E P
MMG	MOPAR Multi-Purpose Grease †
MPG	MOPAR Multi-Purpose Grease †
MPO	Multi-Purpose Gear Oil (API-GL5)
PSF	Power Steering Fluid (see text)
S	Manifold Heat Control Solvent

† Or Equivalent

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4. To answer the following questions, refer to the lubrication chart for 1986 General Motors vehicles. See the following page.

   a. Should API SE/CC engine oil be used for these vehicles?

   _____

   b. What fluid should be used in a four-speed manual transmission for a 1986 Pontiac Firebird?

   _____

   c. What fluid should be used in a four-speed manual transmission for a 1986 Buick Regal?

   _____

   d. What lubricant should be used in standard rear-axle differentials?

   _____

   e. What lubricant should be used in a three-speed manual transaxle for a 1986 Pontiac Fiero?

   _____

   f. What type of antifreeze should be used for engine coolant?

   _____

   g. What type of lubricant should be used on automatic transmission/transaxle shift linkages?

   _____

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USAGE	FLUID/LUBRICANT
Engine Oil	GM Goodwrench Motor Oil or equivalent for API service, SF/CC or SF/CD of the recommended viscosity.
Engine Coolant	Mixture of water and good quality ethylene glycol base antifreeze conforming to GM spec. 1825M (GM Part No. 1052753)
Brake and Hydraulic Clutch Systems	Delco Supreme 11 Fluid (GM Part No. 1052535) or DOT-3 Fluid
Parking Brake Cables	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Power Steering System	GM power steering fluid, Part No. 1050017 or equivalent
Manual Steering Gear (recirculating ball)	Use lubricant meeting requirements of GM-4673-M (GM Part No. 1052182)
Automatic Transmission/Transaxle and 5 speed Manual Transmissions	DEXRON®-II Automatic Transmission Fluid (GM Part No. 1051855)
Manual Transaxle	SAE 5W-30 (GM Part No. 1052931) Manual Transaxle Fluid
Manual Transmission (rear-wheel-drive) 3 and 4 speed	Corvette overdrive unit and Pontiac Firebird 4 speed manual — DEXRON®-II All others SAE-80W gear lubricant (GM Part No. 1052271)
Manual Transmission/Transaxle Shift Linkage	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Key Lock Cylinders	Light oil or general purpose silicone lubricant (GM Part No. 1052276)
Automatic Transmission/Transaxle Shift Linkage	Engine Oil
Clutch Linkage Pivot Points	Engine Oil
Floor Shift Linkage	Engine Oil
Power Antenna Mast	Light Oil (GM Part No. 1052949)
Chassis Lubrication	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Standard Differential Rear Axle	SAE 80W or SAE 80W-90 GL-5 (SAE 80W GL-5 in Canada) gear lubricant (GM Part No. 1052271)
Limited-Slip Differential Rear Axle	Some models require a special gear lubricant additive in addition to (GM Part No. 1052271)*
Windshield Washer Solvent	GM Optikleen Washer Solvent (GM Part No. 1051515) or equivalent

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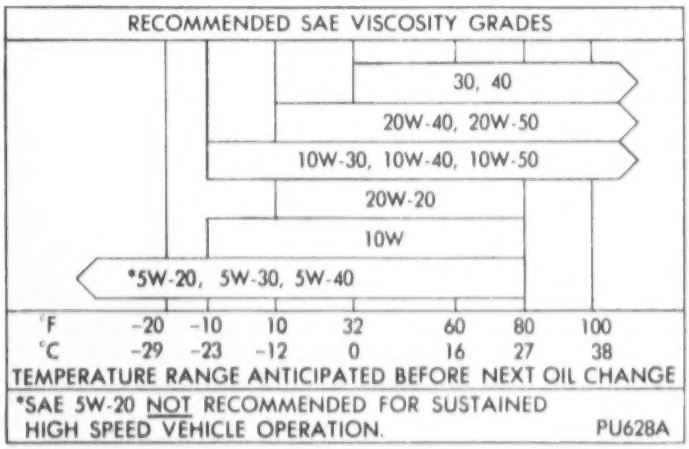
5. To answer the following questions, refer to the viscosity chart below.


RECOMMENDED SAE VISCOSITY GRADES
30, 40
20W-40, 20W-50
10W-30, 10W-40, 10W-50
20W-20
10W
*5W-20, 5W-30, 5W-40
°F -20 -10 10 32 60 80 100
°C -29 -23 -12 0 16 27 38
TEMPERATURE RANGE ANTICIPATED BEFORE NEXT OIL CHANGE
*SAE 5W-20 NOT RECOMMENDED FOR SUSTAINED HIGH SPEED VEHICLE OPERATION.
PU628A

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a. If the vehicle is to be operated where the temperature range will be between 50°F and 90°F, what viscosity grades can be used?

_____

_____

b. If the vehicle is to be operated where the temperature range will be between 0°F and 50°F, what viscosity grades can be used?

_____

_____

c. If the vehicle is to be operated at sustained high speeds where the temperature range will be between −30°F and 32°F, what viscosity grades can be used?

_____

_____

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ASSIGNMENT ANSWERS

MAINTAIN FLUIDS AND LUBRICANTS

ASSIGNMENT SHEET 1

1. a. Dexron II
   b. Dexron II
   c. Dexron II
   d. Dexron II
   e. Dexron
   f. Type F or G
   g. Dexron II

2. a. 10-W-30 engine oil
   b. Dexron II
   c. Dexron II
   d. SAE-90 (GL-4)

3. a. Multi-Purpose Grease, NLG1 Grade 2 E.P.; MOPAR Multi-Purpose Grease
   b. Multi-Purpose Oil (API-GL5)
   c. Multi-Purpose Grease, NLG1 Grade 2 E.P.; MOPAR Multi-Purpose Grease
   d. Dexron, MPO SAE 90, MPO 75W, MPO 75W-80, MPO 80W-90
   e. SAE 30 engine oil
   f. Hi-Temp.-DOT 3
   g. Yes
   h. First time: 24,000 miles
   i. Every 12 months or 12,000 miles

4. a. No
   b. Dexron II
   c. SAE-80W
   d. SAE-80W or SAE 80W-90 GL-5 gear lubricant
   e. SAE 50W-30 manual transaxle fluid
   f. Good-quality ethylene glycol
   g. Engine oil

5. a. SAE 30, 40, 20W-40, 20W-50, 10W-30, 10W-40, and 10W-50
   b. 10W-30, 10W-40, 10W-50, 10W, 5W-20, 5W-30, and 5W-40
   c. 5W-30 and 5W-40

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ACTIVITY SHEET	MAINTAIN FLUIDS AND LUBRICANTS

ACTIVITY SHEET 1

Recommend fluid and lubricant service

Name _____

INTRODUCTION

Much of the work done by a service specialist involves doing routine maintenance on systems that use fluids or require periodic lubrication. Customers have to be able to depend on service specialists to determine service requirements and suitable products for their particular vehicles and the ways in which they use their vehicles. In order to give this kind of advice, the service specialist must know how to determine service requirements and how to modify normal service to suit the particular region, climate, and driving habits of the customer. This means that the service specialist must be able to use reference materials, evaluate customer driving needs, and work with customers to determine a plan for service.

DIRECTIONS

Read the case studies below. For each situation, decide what recommendations you should make to the customer and how you would give that advice. Write your answers in the spaces provided.

SITUATION 1

A customer has brought in a 1984 Buick Riviera with a 252-cubic-inch engine and with 38,628 miles on the odometer. The customer has recently purchased the car and is seeking your advice on servicing the vehicle. You find a service sticker on the doorpost that shows that the vehicle received an oil and filter change at 35,000 miles using SAE 10W-40 Pennzoil. At that time the vehicle's steering, suspension, and chassis were lubricated. When you check the vehicle's fluid levels, all levels are normal, except the engine-oil level, which is slightly below the ADD mark.

a. What recommendations would you suggest to the customer for immediate service, assuming that the vehicle is located where you are now at this time of year?

_____

_____

_____

b. What recommendations would you make for a long-term service plan?

_____

_____

_____

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SITUATION 2

A customer has brought in a 1978 Mercury Marquis with a 400-cubic-inch engine and 93,711 miles on the odometer. The customer complains that the automatic transmission has been leaking for a couple of months and that in the past few days the changes from one gear to another have taken a long time and then have been hard and jerky. The customer is the original owner of the car. When you ask him what service has been done to the transmission, he replies that the only service ever required was to add about a quart of ATF during the past month. You ask what kind of fluid he used, and he answers that he doesn't know. He explains that he didn't know there was a difference; he just added some when he found out that it was low. When you check the fluid, the level is slightly low, and the fluid is dark and has an odor. The leak appears to come from the joint between the engine and the transmission bell housing.

a. What recommendation for service would you make to the customer?

_____

_____

_____

_____

b. What information would you tell the customer about ATFs?

_____

_____

_____

_____

SITUATION 3

A customer brings a 1985 Plymouth Turismo Duster into your shop. The car has 28,014 miles on the odometer and a 2.2-liter engine. The customer asks you to do whatever service needs to be done. She explains that the oil has been changed three or four times and the spark plugs were changed once. The car shows no problems when you test drive it.

a. What routine service would you recommend for the vehicle?

_____

_____

_____

_____

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b. As you perform the required service, you find all fluid levels to be normal and no leaks. However, you discover that the dust boot for the driver's side constant-velocity joint has a tear in it. What advice would you give the customer?

_____

_____

_____

_____

_____

c. You give the customer an estimate of the costs for repairing the dust boot as well as for doing the routine service. She tells you that she only has a certain amount of money that she can spend on the car each month. She says that she can afford to pay either for the dust-boot repair service or for the routine service but not for both. What advice would you give the customer?

_____

_____

_____

_____

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JOB SHEET 1	MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 3 **Lubricate steering and suspension systems**

INTRODUCTION

Many parts of the steering and suspension systems have to be lubricated in order to work correctly and last their expected service life. The four most common methods of lubricating such parts are

- Surface application
- Pressure application
- Packing
- Permanent lubrication

Surface application is simply the application of a lubricant such as oil on the surface of parts. This may include squirting oil on linkages, coating a wheel spindle with grease, or filling a gearbox with lubricant.

Pressure application is done with a grease gun or other device that pumps lubricant through an opening in order to reach internal parts, such as joints or bearings. Pressure application is often done through a special valve called a *zerk* or grease fitting. The zerk allows lubricant to flow into an opening but prevents it from coming out.

Packing is a form of pressure application that is done by hand or with a special tool. Packing is accomplished by squeezing lubricant through openings to fill an internal space such as the packing of wheel bearings.

Permanent lubrication means that the parts are lubricated prior to assembly and then sealed when assembled. No service is required other than replacement of the component. Most factory-original universal joints are permanently lubricated, as are clutch throw-out bearings, starter armature-shaft bushings, and other parts. Some parts are termed *semipermanently lubricated*, which means that lubrication is required but only after a longer-than-normal time. For example, a semipermanently lubricated ball joint may have a lubrication interval of 36,000 miles. It may even have a plugged hole into which a grease fitting must be installed to allow lubrication.

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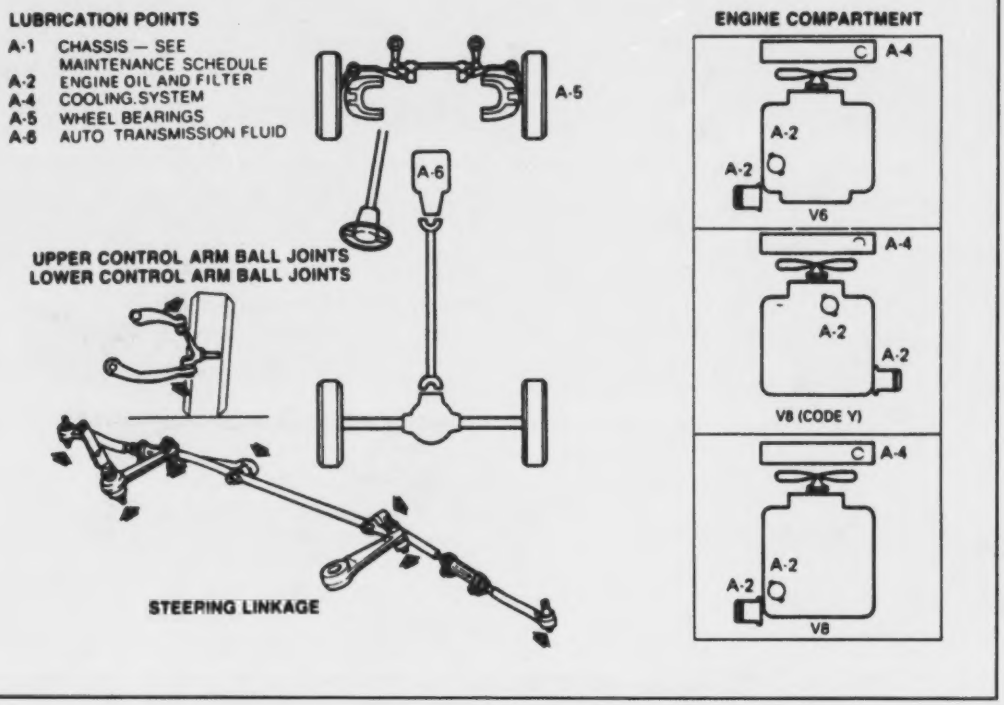
Service manuals contain charts and instructions on what must be lubricated and how often, what type of lubricant to use, and how much is required. Figure 1 below shows a chart of typical lubrication points.

FIGURE 1



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The exact procedures for lubricating steering and suspension parts will vary with the vehicle, the component, and the lubricant. Many of the parts to be lubricated in the steering and suspension system will be covered by rubber *dust boots*. Dust boots cover the lubricated part to keep the lubricant in place and to keep dirt and moisture out, while at the same time, allowing movement of the part. To provide adequate protection, dust boots must be in good condition and proper position. Any time that you are under a vehicle for maintenance, such as during an oil change or a lube job, it is a good practice to check the condition and position of the dust boots. Dust boots split, crack, or develop holes, and can work out of position. Make a particular point of checking the boot that covers the constant-velocity joints on transaxles because dirt and water can quickly ruin such joints. Care must also be used not to apply

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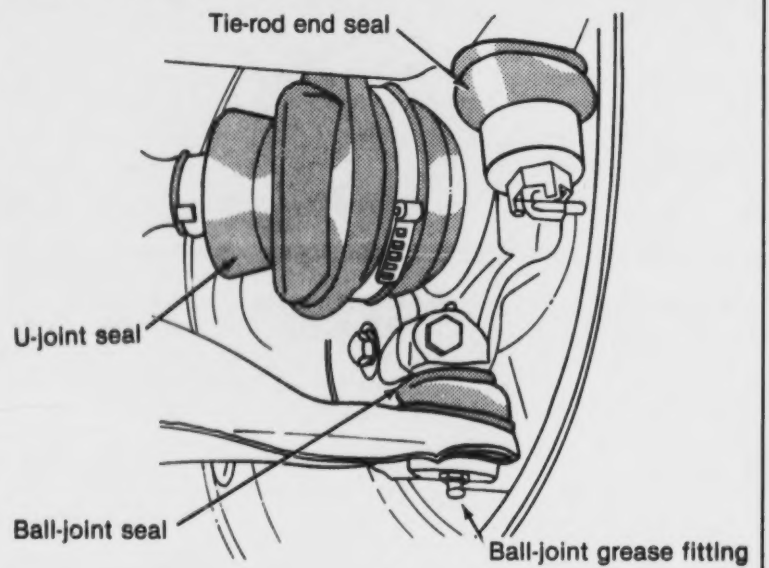
too much pressure or to apply too much lubricant when lubricating dust-boot-covered parts. Excessive pressure or lubricant may rupture the boot or move it out of position. Some typical dust boots are shown by the shaded areas in Figure 2.

FIGURE 2



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It is essential to follow the vehicle manufacturer's recommendations regarding the type of lubricant used. Various lubricants are formulated with specific additives and characteristics for specific applications. For example, when packing wheel bearings on a vehicle with disc brakes, only high-temperature lubricant should be used because the heat produced by disc brakes will melt conventional bearing grease. Some types of rubber will break down in contact with petroleum-based lubricants or other chemicals. For this reason, the manufacturer's recommended lubricant should be used to prevent damage to dust boots, and lubricant should never be applied to rubber bushings.

It does little good to lubricate badly worn parts, so the first step in performing lubrication is to inspect the parts to make sure that they are not worn too badly, that dust boots and seals are not damaged to the point that they will not hold and protect lubricant, and that fittings and other parts involved in the lubrication procedures are clean and usable. This job sheet outlines the steps required to inspect steering and suspension parts prior to lubrication. The exact steps required will vary with different designs and models of vehicles, and you should consult the vehicle manufacturer's service manual.

The procedure for lubrication will vary greatly, not only for the vehicle make and model but also due to the type of lubricating equipment being used. After inspecting the suspension and steering systems, you should refer to the vehicle manufacturer's service manual for lubrication points, procedures, and specifications.

EQUIPMENT AND MATERIALS

As required by procedure

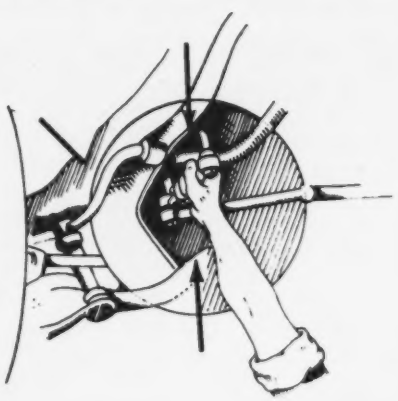
PROCEDURE

NOTE: The procedure given has typical steps required to inspect the steering and suspension systems. Refer to the service manual for exact specifications and for the steps required to lubricate the systems.

1. Clean dirt and grease from suspension and steering parts
2. Check ball joints for wear

   NOTE: On rear-wheel-drive vehicles, the ball joints are normally checked with the vehicle raised so that no pressure is on the ball joints. This requires supporting the upper or lower control arm, depending on which supports the spring. The tire and wheel assembly is then rocked and bounced to see how much the assembly will move. Excessive movement is a sign of worn ball joints. A typical procedure for front-wheel-drive designs is to grasp the ball-joint grease fitting in your fingers and attempt to move it. Again, movement indicates worn parts.
3. Raise vehicle if not already raised
4. Check steering linkages for wear
   a. Check idler arm, if so equipped, by pushing up and pulling down (Figure 3)

FIGURE 3



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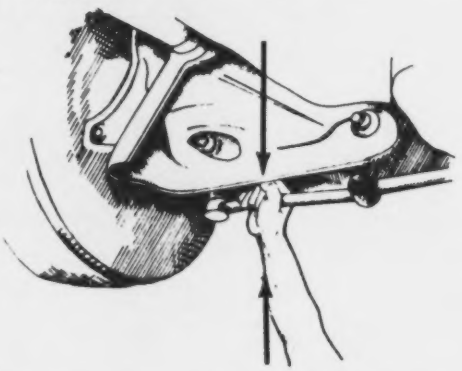
b. Check rod ends by pushing up and pulling down on tie rod (Figure 4)

FIGURE 4



5. Check rubber grommets and dust boots for cracks, tears, leakage, and looseness
6. Check for loose or missing hardware, including nuts, bolts, cotter pins, holding straps, and grease fittings
7. Tighten loose parts that are still usable
8. Replace parts that show excessive wear
9. Perform required lubrication procedures
10. Clean work area and return equipment and materials to proper storage

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JOB SHEET 2

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 4

Lubricate driveline components

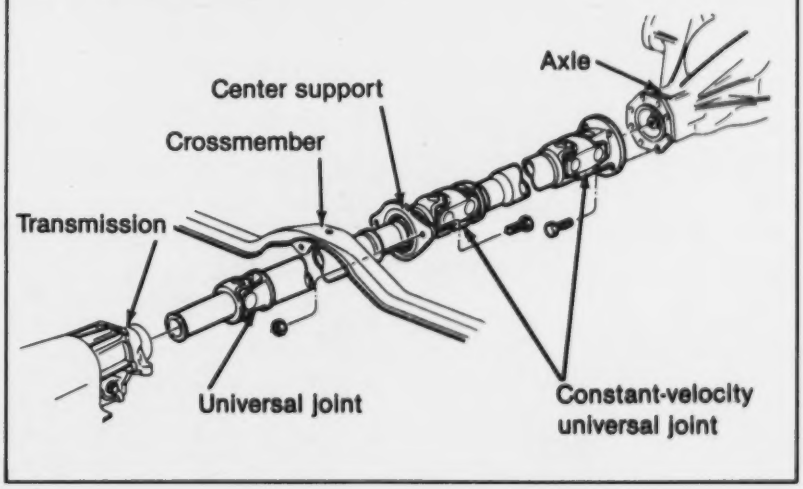
INTRODUCTION

A complete lube job will include steering, suspension, and driveline components. However, most front-wheel-drive vehicles do not permit periodic maintenance on driveline components, and many rear-wheel-drive vehicles come equipped with nonserviceable universal joints, making it unnecessary to lubricate U-joints on low-mileage vehicles. This is not true for vehicles in which the U-joints have been replaced. Most replacement universal joints come with grease fittings and require periodic lubrication.

As with all service, you should refer to the owner's manual or service manual to determine how often lubrication is required, what lubricant should be used, and how the lubricant should be applied. In the case of serviceable replacement parts, lubrication recommendations will come from the part manufacturer. Be aware that if the U-joint has been replaced, lubrication requirements may not be indicated in the service manual. When servicing the driveline, check carefully for zerks or other grease fittings.

Drivelines come in various designs that will differ in the number of U-joints used. Figure 1, for example, shows a *split* drive shaft, which has three universal joints. Make sure that you understand what parts must be lubricated on any particular vehicle.

FIGURE 1



Courtesy Cadillac Motor Car Division, General Motors Corporation.

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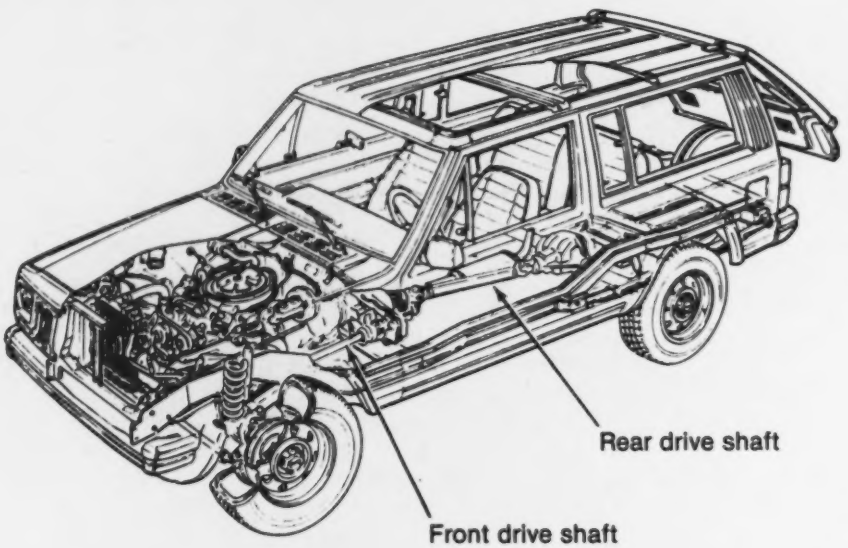
Figure 2 below shows a vehicle with four-wheel drive. Note that it has two drive shafts, both of which must be serviced.

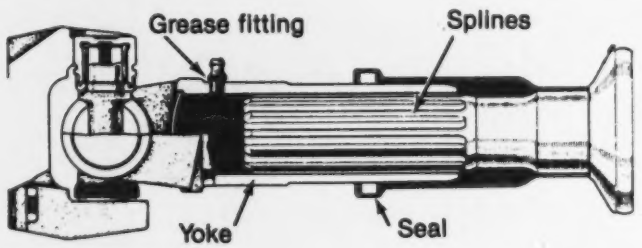
FIGURE 2



Courtesy of Chrysler Motors.

Some drive-shaft designs are equipped with *slip joints* to allow the drive shaft to lengthen or shorten as the vehicle travels over an uneven surface. The slip-joint portion of the shaft is often equipped with a zerk of its own as shown in Figure 3 below.

FIGURE 3



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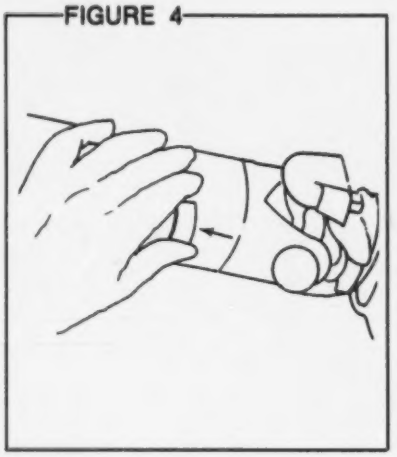
When lubrication maintenance is performed, you should clean and inspect the drive shaft. A precise inspection of the drive shaft, or *propeller shaft* as it is sometimes called, requires the use of special tools to check balance, angles, runout, and other characteristics, and is normally done by a driveline specialist. However, some general checks are possible even in a visual inspection.

Certain precautions must be observed when inspecting the driveline. First, the driveline should be cleaned of dirt, undercoating, or other buildup. A wire brush or putty knife may be used depending on the amount and type of buildup. However, be careful when cleaning the drive shaft because many drive shafts are equipped with balance weights attached by rivets. (See Figure 4.) If these are accidentally knocked off, the shaft will be out of balance and will wobble when it rotates.

FIGURE 4



You should also inspect the drive shafts, joints, and seals for damage and leaks. Small dents do not affect the operation of the shaft as long as they do not change the center line. Check to see also that the balance weights are in place.

Be sure that you locate and identify all lubrication points and follow all recommendations of the vehicle manufacturer.

Use care also because you will be working around exhaust-system components, which may be hot.

EQUIPMENT AND MATERIALS

As required by the procedure

PROCEDURE

NOTE: Refer to the service manual for the make and model of vehicle as equipped.

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JOB SHEET 3

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 6

Change engine oil and filter

INTRODUCTION

An adequate amount of quality engine oil is important to the proper operation and service life of an engine. Also, the appearance of the oil and the rate at which it is consumed during engine operation can be clues as to the condition of the engine. Oil is lost or consumed in two ways: through *leaks* in the lubricating system and through *being burned* in the engine. Some loss through burning is normal because oil vapor is circulated through the PCV system. However, this should amount to no more than a loss of 1 quart of oil for every 1000 to 3000 miles of driving. Consumption may be higher than this in a brand-new engine or in an engine with high mileage.

Oil consumption that is more than expected may be an indication of leaks. The most common areas for leaks include

- Around the valve cover;
- Around the oil-pan mating surfaces;
- At the oil-pan drain plug;
- At the oil filter;
- At the oil-pressure sending unit; and
- At seals around shafts such as the crankshaft or distributor drive shaft.

Any time you change the engine oil, you should check for such leaks, especially if oil consumption is abnormally high. Leaks may also be indicated by puddles of oil under a vehicle that has been parked for awhile.

Excessive oil burning usually results from worn cylinders, valve seals or guides, or piston rings. Besides high oil consumption, blue-gray smoke from the tail pipe may be a sign that a vehicle is burning oil.

Watery or milky oil or high oil levels on the dipstick may be a sign that coolant is leaking into the oil system, such as through a crack in a cylinder or gasket leak. In this situation, repairs must be made to fix the leak and the engine oil changed.

Vehicle manufacturers recommend intervals for normal oil changes and for replacing the oil filter. These intervals are normally given in both distance driven (miles or kilometers) and time between oil changes. There are two important points to remember about these recommended intervals. First, the time/mileage interval is based on data from vehicles driven under ideal conditions in which the useful life of the oil is at its maximum. The interval is considerably shorter for vehicles operated

- Under very dusty or very wet conditions.
- At prolonged high speeds.

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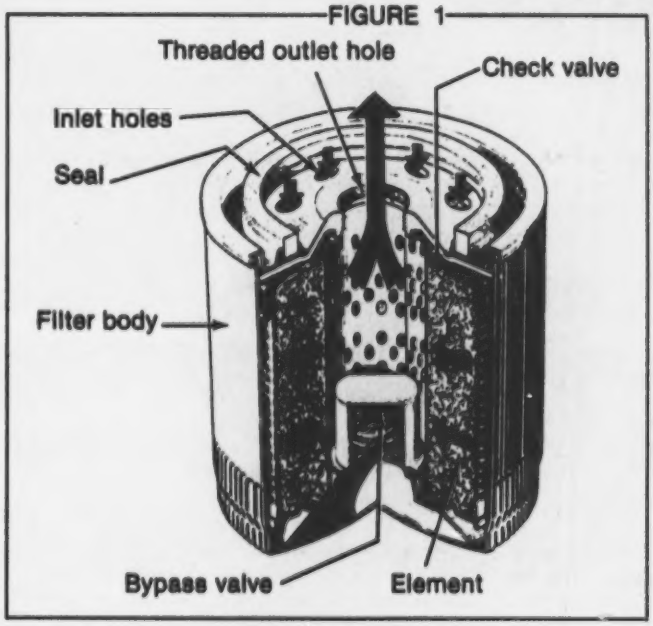
- With engine under heavy loads, such as when vehicle is driven in mountainous areas or pulls a trailer.
- Under conditions requiring frequent short trips when the engine does not reach normal operating temperatures.

All of these situations break down oil and shorten its life as an effective lubricant. Thus, oil changes will have to be more frequent than the manufacturer recommends in vehicles driven under these conditions.

The second point to remember about the manufacturer's recommended oil/filter-change intervals is that both distance and time intervals apply. This means that if the manufacturer recommends an interval of 3000 miles or 3 months, an oil change is required at whichever of those comes first. For example, if the vehicle is not driven frequently and travels only 1700 miles in the 3 months since its last oil change, the oil should be changed. This is because oil breaks down, becomes contaminated by water vapor, and loses its lubricating capability in other ways as it is heated up by occasional driving and then allowed to sit unused. Similarly, if the vehicle were driven on a 4000-mile trip in a two-week period, the oil should be changed after 3000 miles, even though the oil may have been changed just before the start of the trip. Following the manufacturer's recommended intervals will not only increase the service life of the engine, but such maintenance is generally required in order to keep the manufacturer's warranty in effect.

FIGURE 1



Used with permission of Saab-Scania of America.

However, following the manufacturer's recommendations for oil changes will not help much if you fail to change the oil filter. Manufacturers make different recommendations as to whether the filter should be changed at each oil change or every other oil change, so always follow or exceed the manufacturer's requirements. The oil filter is important because it helps to keep the oil free of dirt and contaminants. Detergents in the oil keep the contaminants suspended so that they will be trapped by the filter element. Figure 1 at left shows how the filter is constructed. The filter is attached to the engine block by a threaded shaft. Oil from the oil pan enters the filter by one or more holes and flows through the filter element. The oil then enters the engine block. Most filters are equipped with a bypass valve that allows oil flow even if the element has become completely clogged.

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When changing engine oil, you will need to check the owner's manual or service manual to determine the type, viscosity, and quantity of oil required. Note that the quantity varies depending on whether or not the filter is changed. Additional instructions for installing the filter may be found on the filter package.

EQUIPMENT AND MATERIALS

- Service manual for make and model of vehicle
- Basic hand-tool set
- Oil-filter wrench
- One or more drain pans
- Jack or lift
- Shop rags and fender covers
- Replacement filter
- Engine oil: type and quantity specified by vehicle manufacturer

NOTE: This procedure will apply to most standard engine designs. However, procedures for specific vehicles may vary from what is presented here; refer to the service manual for the exact procedure. The procedure for changing the oil on a vehicle equipped with a turbocharger is covered in Job Sheet 4.

PROCEDURE

1. Run engine until operating temperature is reached, and then shut off engine

   ► WARNING ◄

   If vehicle is run in enclosed area, use exhaust-removal equipment.

2. Raise vehicle

   NOTE: Some manufacturers recommend that the vehicle be level to allow proper drainage. If a lift is not used, it may be necessary to raise both ends of the vehicle and place it on jack stands.

3. Position drain pan to catch oil

4. Loosen oil-pan drain plug with wrench until plug can be turned by hand

5. Grasp drain plug between fingers and loosen with slight inward pressure

6. When drain plug is free of threads, pull plug out of way to allow oil to drain

   CAUTION

   Be careful of the hot oil.

7. Allow oil to drain completely

   NOTE: Some vehicles have more than one drain plug on the oil pan. Be sure to remove additional drain plugs if required.

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8. Clean drain plug and inspect threads; also inspect threads in the pan; replace damaged parts if required

   NOTE: Refer to service manual for replacement procedures. Some pan threads are plastic inserts, and threads in any pan may be stripped easily. Self-tapping replacement plugs are often available.

9. Reinstall drain plug, being careful not to crossthread the plug; tighten to specified torque

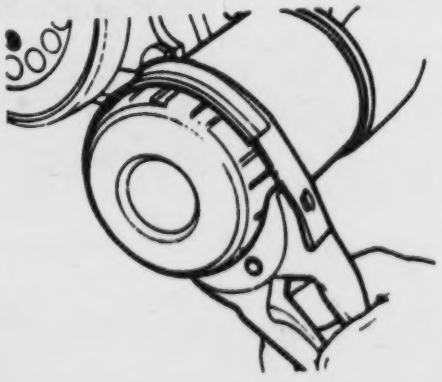
   NOTE: Some drain plugs are equipped with gaskets or O rings. These should be inspected and reused only *if* in good condition. Be sure gaskets or rings seat properly during reinstallation.

10. Reposition the drain pan under the oil filter, if necessary

11. Use oil-filter wrench to remove filter (Figure 2) and pour oil into drain pan

    NOTE: Oil filters are installed in various positions in different locations for each make and model of vehicle. They are sometimes located in confined areas that require the use of a specific type of oil-filter wrench.

FIGURE 2



Used with permission of Chrysler Corporation.

12. Inspect removed filter and attaching surface to be sure gasket or gasket material does not remain on attaching surface; remove if necessary, using wire brush

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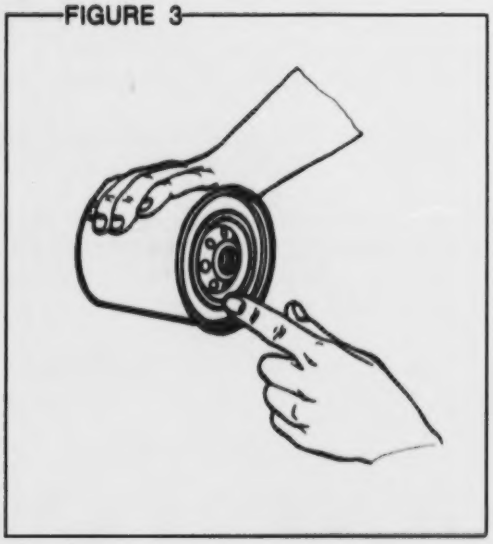
13. Lightly coat gasket of proper replacement filter with new oil (Figure 3)

FIGURE 3



Used with permission of Chrysler Corporation.

14. Install filter on threaded shaft, using care **not** to crossthread filter

15. Tighten filter by hand until gasket contacts attaching surface; turn filter an additional three-quarters of a turn or amount specified by filter manufacturer

CAUTION

Do **not** overtighten and do **not** use a filter wrench for installation.

16. Lower vehicle, open hood, and put fender covers in place

17. Remove oil-filler cap, using care **not** to allow dirt or other contaminants to enter opening

18. Install correct amount of recommended type and viscosity of oil, using clean funnel if necessary

19. Clean up any spilled oil and replace filler cap

20. With exhaust-removal equipment in place, start engine and allow to idle at low speed

21. Check that oil-pressure light goes out or that oil-pressure gauge reaches required reading

CAUTION

If required oil-pressure indication is **not** observed after 30 seconds of running the engine, shut off the engine and report the problem to your instructor.

22. Check for leaks around oil drain plug and filter; check for proper installation if leaks occur, and then replace or reinstall parts as required

23. Turn off engine

24. After about 10 minutes, check oil level; adjust if necessary

25. Record service, as required, noting date, vehicle mileage, and type and weight of oil

26. Dispose of used oil and filter properly

► WARNING ◄

Used engine oil is a toxic substance. Follow required procedures for proper disposal.

27. Clean work area and put away tools and equipment

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JOB SHEET 4

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 7

Change engine oil in a vehicle equipped with a turbocharger

INTRODUCTION

The high speeds at which turbocharger shafts operate mean that effective lubrication is critical. Oil used to lubricate a shaft spinning at 130,000 rpm or more must provide the best lubrication possible. Also, parts operating at such high speeds must be protected from dirt and corrosion to preserve the near-perfect balance and force distribution required.

Thus, the service specialist must be especially mindful of maintenance requirements for turbocharged engines. One particular service danger is failing to make sure that the turbocharger is properly lubricated after an oil change. Each vehicle manufacturer provides specific instructions on how to build up oil pressure in the turbocharger after an oil change. Generally, this will involve cranking the engine with the ignition system disabled so that no exhaust gases are produced to turn the turbine. However, you must refer to the vehicle manufacturer's service manual for the exact procedure.

Even the operation of a turbocharged engine requires some special precautions that you as a service specialist need to observe in operating such vehicles around the shop. One is that the engine rpm should be allowed to build slowly. Do not start a turbocharged engine and immediately race up the engine speed. Also, if the engine has been running at high speed, allow it to idle down for a few minutes before shutting it off to allow the turbine shaft to slow down while oil is still circulating. Both of these techniques will help to maintain adequate oil pressure. Care must also be taken not to close the throttle suddenly while the engine is running at high speeds. This results in compressed air being forced into the combustion chamber without enough fuel, leading to a very lean mixture at a very high temperature.

It is a good idea to review the owner's manual for operating instructions for any vehicle equipped with a turbocharger or other features with which you are unfamiliar.

Turbochargers are expensive, and little repair work can be done on them in the shop. Many turbochargers have been ruined by service specialists who failed to follow the required procedures for proper start-up after an oil change. Make sure that you are not one of them. Paying for a turbocharger can sure cut into your paycheck.

1167

EQUIPMENT AND MATERIALS

As required for procedure

PROCEDURE

NOTE: Refer to service manual for make and model of vehicle as equipped. Follow the guidelines in Job Sheet 3 and any special requirements necessary for a turbocharged engine.

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JOB SHEET 5	MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 10 Adjust fluid levels

INTRODUCTION

Just as there are many different types of fluids used in a modern vehicle, there are also many ways of checking and adjusting fluid levels. Fluid levels are usually checked with a dipstick, as is the case with engine oil, power-steering fluid, and automatic-transmission fluid. The level for some fluids is checked visually, as with coolant and brake fluid. You studied these procedures in Unit A-5, "Study Automotive Design."

A third method for checking fluid levels is commonly used for gearboxes such as differentials, manual transmissions, and some steering gears. This method requires the service specialist to insert a finger in the fill hole of the component to check to see how close to the hole the fluid is. As with checking any fluid level, the vehicle must be level when performing this check. Care must also be used not to contact any gears in the component, as these can be very sharp.

Most fluids are to be maintained within a specific range of levels. They should be neither too low or too full. Obviously, if the level is too low, then there may not be enough fluid to effectively do the job. This may result in increased wear and overheating if the engine oil is low, or in rough shifting and increased wear if the automatic-transmission fluid is low.

Similarly, high fluid levels may cause problems. At the least, adding too much fluid is wasteful because many fluid systems have overflows. But too much fluid may actually damage some systems or cause them to work inefficiently. For example, too much transmission fluid in an automatic transmission will cause the transmission parts to churn air into the fluid. This leads to poor shifting and damage due to varnish buildup, increased corrosion, and overheating. In some systems too much fluid may lead to excessive pressure, which again interferes with proper operation and may cause damage.

Fluid level and condition can be important signals of how the system is working and of problems that may be present. When you check the fluid it should be clean and free of metal particles. There should be no darkening of the fluid or other signs of burning, such as an odor. The service manual will specify fluid conditions and their indications for each particular application.

A system that frequently needs fluid added is another indication of a problem. In most cases, this will be caused by a leak in the system. However, drops in fluid level may also indicate a malfunction in the system itself. The system may be burning the fluid, or worn parts may allow fluid to escape without an indication of a leak. All of these factors should be considered when checking and adjusting fluid levels, and repairs should be made.

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Most service manuals are fairly clear in their instructions for adding fluid, and this is the most commonly required procedure. To lower the fluid level, a drain plug is used for most systems. However, in some cases, there are no drain plugs, and another method must be used. For example, fluid can be removed from a differential with a syphon pump. Whenever a device is used to remove fluid from a system, make sure that it is clean and that no contaminants are introduced into the system.

Be careful also not to add air in the system and not to open a system that is sealed from air, such as the brake system.

Whenever handling fluids, follow all requirements for that particular fluid. For example, be careful not to allow fluids that will damage vehicle finishes, such as brake fluid, to contact painted surfaces. Do not get fluids in your eyes and avoid contact with those that can damage your skin. Use care around flammable fluids to avoid fires and explosions. Dispose of all fluids properly.

One special concern when adding fluid to a system is whether the fluid is the correct one. Not only must the fluid meet all the vehicle manufacturer's requirements, but it must be compatible with the fluid already in the system. Fluids that are not compatible may not mix well. This can prevent the system from operating correctly or can prevent either fluid from doing what it is designed to do. For example, oil added to an engine should be the same API type and SAE weight as that in the system. Silicone brake fluid should never be added to glycol-based fluids. If an automatic transmission has Type F ATF, Dexron ATF should not be added—even if the vehicle manufacturer says either type is acceptable. Assuring compatibility is one reason why it is important to keep complete and accurate service records. If you are in doubt about the fluid already in the system and have to add some, the best thing to do is to drain the system and refill it.

Be sure to follow the manufacturer's procedures for each particular vehicle as equipped. Fluid requirements and capacities for one particular engine size may differ for vehicles with different transmissions, with air conditioning, and with other options.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped.

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JOB SHEET 6

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 11

Flush cooling system

INTRODUCTION

To clean the cooling sytem, a technique called *flushing* is used. There are three basic flushing techniques—all involving the use of water under pressure to wash rust and corrosion from the radiator. One method, called *fast flushing*, requires that a water supply be connected to a heater hose. Water is run through the engine or the radiator in the opposite direction of normal flow. Another method, called *reverse flushing*, requires a special flushing gun for flushing of either the radiator or the engine. The last flushing method, *chemical flushing*, requires the use of a chemical that is added to the cooling system before it is flushed. The chemical is added to the system and allowed to remain in it for a time or distance specified by the chemical manufacturer and then the system is flushed, usually by reverse flushing.

Each vehicle manufacturer makes recommendations about the acceptable flushing method for its vehicles. These must be followed exactly to avoid damage to the cooling system. Similarly, the instructions provided by the manufacturers of flushing equipment must be followed. The instructions may require removal of the thermostat, for example, and failing to do so may damage the cooling system or the flushing equipment, or may prevent a thorough flushing.

Following the directions for use of chemical cleaning agents is especially important. Some of these chemicals are very strong acids that can damage cooling-system components and can cause serious personal injury, especially to the eyes and skin. Many of these chemicals require the use of a second chemical to neutralize the effects of the first. Before using any chemical flushing agent, be sure you understand the directions for its use, the safety precautions to follow during its use, and all emergency procedures in the event of an accident during use.

The need to flush the cooling system may be indicated by any of the following:

- Rust or scale (deposits) in the cooling system.
- High cooling-system pressure.
- Engine's overheating.
- Manufacturer's service recommendations.

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EQUIPMENT AND MATERIALS

As required for the type of flushing to be done in accordance with the vehicle manufacturer's recommendations for the make and model as equipped

PROCEDURE

NOTE: Refer to the vehicle manufacturer's service manual. Also follow directions provided by the flushing-equipment manufacturer. If chemical flushing is used, comply with the flushing-agent manufacturer's instructions and precautions.

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PRACTICAL TEST	MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 1

Lubricate steering and suspension systems

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared and raised vehicle properly.	_____	_____
3. Performed system checks outlined in procedure.	_____	_____
4. Performed required lubrication procedures.	_____	_____
5. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1173

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1174

PRACTICAL TEST

MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 2

Lubricate driveline components

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Completed system inspection.	_____	_____
3. Properly located and identified lubrication points.	_____	_____
4. Followed proper procedure.	_____	_____
5. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1175

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1176

PRACTICAL TEST

MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 3

Change engine oil and filter

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared and raised vehicle properly.	_____	_____
3. Properly drained oil and removed filter.	_____	_____
4. Properly installed filter.	_____	_____
5. Installed correct amount of recommended oil.	_____	_____
6. Checked for proper installation of oil and filter.	_____	_____
7. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1177

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 4

Change engine oil in a vehicle equipped with a turbocharger

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed proper procedure.	_____	_____
3. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1179

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 5

Adjust fluid levels

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Completed system inspection.	_____	_____
3. Adjusted fluid levels according to manufacturer's specifications.	_____	_____
2. Followed proper procedure.	_____	_____
5. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1161

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

MAINTAIN FLUIDS AND LUBRICANTS

JOB SHEET 6

Flush cooling system

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed procedure recommended by vehicle manufacturer.	_____	_____
3. Cleaned work area and properly disposed of waste materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key".) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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WRITTEN TEST

MAINTAIN FLUIDS AND LUBRICANTS

Name _____ Score _____

OBJECTIVE 1

Choose the definition that best defines the following terms associated with maintaining fluids and lubricants. Write the correct numbers in the blanks.

_____a. **Fluid**

1. Substance that flows
2. Substance used to help parts in contact move more easily
3. Substance used to power gasoline engines
4. Substance used to hold parts together

_____b. **Lubricant**

1. Substance used to hold parts together
2. Source of friction
3. Substance used to help parts in contact move more easily
4. Substance used to power gasoline engines

_____c. **Filter**

1. Device used to control direction of fluid flow
2. Device used to increase engine power by forcing more air/fuel mixture into combustion chamber
3. Device used to control amount of fluid pressure in system
4. Device used to remove foreign materials from substance moving through it

_____d. **Turbocharger**

1. Device used to restore battery state of charge
2. Device used to increase engine power by forcing more air/fuel mixture into combustion chamber
3. Device equipped with impellers designed to circulate fluids through a closed system
4. Device used to remove foreign materials from substance moving through it

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_____e. **Viscosity**

1. Measure of the weight of a quart of engine oil
2. Measure of the clarity of a fluid
3. Measure of the purity of a substance
4. Measure of how easily a liquid flows

_____f. **Inhibitor**

1. Chemical added to fluid or lubricant to prevent some action from taking place
2. Device used to prevent engine speed from becoming excessive
3. Chemical added to fluid or lubricant to reduce friction between substance and moving parts
4. Device used to indicate pressure readings in fluid systems

_____g. **MPO** — Abbreviation for

1. Modified petroleum oxidizer, a substance added to fluids and lubricants to reduce corrosion
2. Multiviscosity petroleum oil, a synthetic engine oil
3. Mileage-producing oil, a special blend of engine oil designed to increase fuel economy
4. Multipurpose gear oil, a lubricant used in transmissions, differentials, and other gearboxes

_____h. **Sustained**

1. Continued for a long time
2. Marked by increasing fluid pressure
3. Corroded
4. Flowing easily

_____i. **Acid**

1. Chemical added to fluid or lubricant to prevent some action from taking place
2. Substance used to help parts in contact move more easily
3. Substance used to break loose rusted or corroded parts
4. Chemical that breaks down other substances

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OBJECTIVE 2

Match fluids and lubricants to their correct descriptions. Write the correct numbers in the blanks.

_____a. Petroleum-based or synthetic liquid designed to reduce wear of engine parts

_____b. Petroleum-based liquid that is generally heavier than engine oil; used in gearboxes such as manual transmissions and differentials

_____c. Thick lubricant made from petroleum and a mixture of fatty acids and soft metals, such as calcium or lead; used on bearings and joints

_____d. Soft carbon powder, sometimes mixed with grease or oil; used to lubricate door and trunk lock mechanisms and some electrical components, such as starter motors

_____e. Dry lubricant used on rubber and plastic parts, such as weatherstripping

_____f. Soft, solid substance such as paraffin used on door latches and striker posts

_____g. Petroleum-based oil used to transmit hydraulic power

_____h. Nonpetroleum fluid used for brake systems and some clutch systems for manual transmissions

_____i. Alcohol-based (usually ethylene glycol) liquid mixed with water to provide better cooling, reduce rust and corrosion, and prevent freezing of coolant

_____j. Petroleum-based oil formulated to allow quicker response to pressure changes than most ATFs provide

1. Engine oil
2. Silicone
3. Wax
4. Power-steering fluid
5. Grease
6. Automatic-transmission fluid (ATF)
7. Graphite
8. Gear oil
9. Antifreeze
10. Brake fluid

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OBJECTIVE 5

Write the meaning of the engine-oil ratings listed below by completing the following statements.

Viscosity rating

a. Indicates _____

_____

_____

b. Represented by _____

_____

_____

c. The thicker the oil remains at high temperatures,

_____

_____

Service rating

a. Indicates _____

_____

_____

_____

b. Represented by _____,

which refer to _____

_____

c. The more the oil has been chemically modified,

_____

_____

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OBJECTIVE 8

Choose the correct description for each of the following automotive fluids. Write the correct numbers in the blanks.

_____a. **Automatic-transmission fluid**

1. Label carries a manufacturer's code that designates fluid's specific viscosity to work best with the materials and openings in a particular transmission/transaxle design; fluid contains an orange dye to distinguish it from other fluids
2. Label carries a manufacturer's code that designates fluid's specific viscosity to work best with the materials and openings in a particular transmission/transaxle design; fluid contains a red dye to distinguish it from other fluids
3. Label carries a Department of Transportation (DOT) code; fluid contains an orange dye to distinguish it from other fluids
4. Label carries a Department of Transportation (DOT) code; fluid contains a red dye to distinguish it from other fluids

_____b. **Brake fluid**

1. Label carries a Department of Transportation (DOT) numerical code
2. Label carries a Department of Transportation (DOT) letter code; fluid is identified by its base substance, silicone or glycol
3. Label carries a Department of Transportation (DOT) numerical code; fluid is classed as either petroleum-based or non-petroleum-based
4. Label carries a Department of Transportation (DOT) letter code; fluid is classed as either petroleum-based or non-petroleum-based

_____c. **Antifreeze**

1. Label gives mixing instructions for various protection levels and lists restrictions for use of corrosion inhibitors and lubricants with various cooling-system materials
2. Label carries a classification of either petroleum- or non-petroleum-based and quotes the level of freeze protection given by certain mixture percentages
3. Label carries a rating based on the percentage of water and base fluid in the mixture; base fluid consists of silicone or glycol
4. Label carries a rating recommending either winter or summer use; rating is based on the freezing point of winter coolant or the boiling point of summer coolant

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_____d. **Power-steering fluid**

1. Label carries a Department of Transportation (DOT) numerical rating
2. Label carries the same manufacturer's coding system used for automatic-transmission fluid
3. Label lists suitability recommendations that are based on specific flow-control properties for the quick changes in pressure and gear positions required
4. Label carries a classification number based on fluid's viscosity weight

OBJECTIVE 9

Study the lubrication chart on the next page to answer the following questions about fluid and lubricant requirements.

a. What two fluids may be used in the hydraulic clutch system?

1. _____

2. _____

b. What steering fluid should be used for the power-steering system?

_____

c. What lubricant is used for the floor-shift linkage?

_____

d. What fluid or lubricant should be used in most automobiles with 3- and 4-speed manual transmissions (rear-wheel drive)?

_____

e. What American gear lubricant is specified for the standard differential rear axle?

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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USAGE	FLUID/LUBRICANT
Engine Oil	GM Goodwrench Motor Oil or equivalent for API Service, SF/CC or SF/CD of the recommended viscosity
Engine Coolant	Mixture of water and a good quality ethylene glycol base antifreeze conforming to GM spec. 1825M (GM Part No.1052753)
Brake and Hydraulic Clutch Systems	Delco Supreme 11 Fluid (GM Part No. 1052535) or DOT-3 Fluid
Parking Brake Cables	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Power Steering System	GM Power Steering Fluid, Part No. 1050017 or equivalent
Manual Steering Gear (recirculating ball)	Use lubricant meeting requirements of GM-4673-M (GM Part No. 1052182)
Automatic Transmission/Transaxle and 5 speed Manual Transmissions	DEXRON® II Automatic Transmission Fluid (GM Part No. 1051855)
Manual Transaxle	SAE-5W-30 (GM Part No. 1052931) Manual Transaxle Fluid
Manual Transmission (rear-wheel-drive) 3 and 4 speed	Corvette overdrive unit and Pontiac Firebird 4 speed manual—DEXRON®-II. All others SAE-80W gear lubricant (GM Part No. 1052271)
Manual Transmission/Transaxle Shift Linkage	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Key Lock Cylinders	Light oil or general-purpose silicone lubricant (GM Part No. 1052276)
Automatic Transmission/Transaxle Shift Linkage	Engine Oil
Clutch Linkage Pivot Points	Engine Oil
Floor Shift Linkage	Engine Oil
Power Antenna Mast	Light Oil (GM Part No. 1052949)
Chassis Lubrication	Chassis grease meeting requirements of GM-6031M (GM Part No. 1052497)
Standard Differential Rear Axle	SAE 80W or SAE 80W-90 GL-5 (SAE 80W GL-5 in Canada) gear lubricant (GM Part No. 1052271)
Limited-Slip Differential Rear Axle	Some models require a special gear lubricant additive in addition to (GM Part No. 1052271)*
Windshield Washer Solvent	GM Optikleen washer solvent (GM Part No. 1051515) or equivalent

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WRITTEN TEST ANSWERS

MAINTAIN FLUIDS AND LUBRICANTS

OBJECTIVE 1

a. 1
b. 3
c. 4
d. 2
e. 4
f. 1
g. 4
h. 1
i. 4

OBJECTIVE 2

a. 1
b. 8
c. 5
d. 7
e. 2
f. 3
g. 6
h. 10
i. 9
j. 4

OBJECTIVE 5

Viscosity rating

a. Indicates oil's thickness when heated in comparison to other oils
b. Represented by a number
c. The thicker the oil remains at high temperatures, the higher the number

Service rating

a. Indicates oil's suitability for use in certain types of engines and the amount of chemical modification that was done to the oil when it was refined
b. Represented by two letters which refer to engine type and level of chemical modification
c. The more the oil has been chemically modified, the farther from A in the alphabet is the second letter

OBJECTIVE 8

a. 2
b. 1
c. 1
d. 3

OBJECTIVE 9

a. 1. Delco Supreme II Fluid
   2. DOT-3
b. GM power-steering fluid 1050017 or equivalent
c. Engine oil
d. SAE 80W gear lubricant
e. SAE 80W or SAE 80W-90 GL-5

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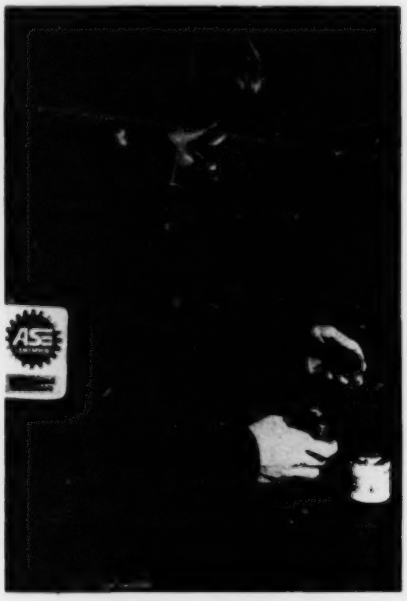
OBJECTIVE SHEET

UNIT B-5 REMOVE AND REPLACE SEALS AND GASKETS

INTRODUCTION



The extensive use of fluids and lubricants in automotive design requires methods of sealing moving and nonmoving automotive parts so that the fluids and lubricants will not leak. For nonmoving parts this is accomplished through the use of special materials between joined parts. The materials compress slightly to mold to the shape of the parts and to fill small irregularities in the mating surfaces. These materials are called seals, and they are used in automotive construction to prevent leakage of fluids, lubricants, and fuel exhaust gases circulating through automotive systems. They also keep out water, dirt, and other contaminants. Seals perform all these functions with moving parts. The automotive service specialist must know how to remove and replace seals and gaskets to properly protect automotive systems.

UNIT OBJECTIVE

After completing this unit, the student should be able to remove and replace seals and gaskets. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

PREREQUISITES

Before studying this unit, the student must have successfully completed Unit B-4, "Maintain Fluids and Lubricants."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recall definitions of *seal* and *gasket* by writing their definitions.
2. Recognize definitions of terms associated with automotive seals and gaskets by choosing the correct definition from a list of three choices.

3. Recall types of automotive gaskets and their descriptions by writing each type and its description.

4. Apply guidelines for replacing gaskets. (Assignment Sheet 1)

5. Replace a formed gasket. (Job Sheet 1)

6. Replace a formed-in-place gasket. (Job Sheet 2)

7. Cut a gasket. (Job Sheet 3)

8. Recall types of automotive seals and their descriptions by writing each type and its description.

9. Replace a seal. (Job Sheet 4)

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SUGGESTED ACTIVITIES	REMOVE AND REPLACE SEALS AND GASKETS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstrations of job-sheet procedures if unable to obtain suitable media.

- Obtain transparencies and competency profiles for this unit.

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare classroom and shop. Display posters, charts, safety signs, etc., that emphasize seals and gaskets. Have service manuals, professional manuals, mock-ups, and other references about seals and gaskets available for student use. Display various types and brands of seals and gaskets.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss introduction to the unit (see Objective Sheet). Show the class some of the many and varied types of seals and gaskets. Explain to students the purpose of using seals and gaskets, stressing the vital role that seals and gaskets play within the vehicle's many systems. Discuss some of the more common instances requiring seal and gasket replacement. Also give students examples of a few less common instances.

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive service specialist. Also relate the objectives to your introduction and to materials previously covered.

Objective 1 Recognize definitions of *seal* and *gasket*

- Show students a seal and a gasket. Discuss their definitions, and explain that the two terms are not interchangeable.

- Explain that gaskets are used to prevent leakage between nonmoving parts and that seals are used to prevent leakage between moving parts. Use mock-ups or disassembled components requiring seals or gaskets to demonstrate their functions.

- Discuss box material, "Seals and Sealers."

Objective 2 Recognize definitions of terms associated with automotive seals and gaskets

- Point to examples that illustrate terms in the shop and make examples available in the classroom.

- Discuss the term *sealer*, and explain that a sealer can be used to make a seal, can be used with a gasket to seal components, or can be used to make a *formed-in-place* gasket.

Objective 3 Recall types of automotive gaskets and their descriptions

- Discuss with students the three types of gaskets and their applications.

- Tell students that formed gaskets are made from a variety of materials or are made of a combination of different materials in order to function properly in different vehicle systems.

- Explain to students that formed-in-place gaskets are made by using a *sealer*, and discuss again the definitions of *sealer*, *seal*, and *gasket*.

- Display a variety of formed gaskets, pointing out those which could be replaced with formed-in-place or user-formed gaskets.

- Tell students of instances when it is likely that the service specialist would use a user-formed gasket. Have students list occasions when these gaskets could be used.

Objective 4 Apply guidelines for replacing gaskets

- Have students study Student Supplement 1 "Gasket Guidelines."
- Discuss with students the different gasket materials and their features and applications. Explain that certain types of gaskets are made available of only certain materials. For example, a formed gasket of steel is available for a head gasket, but a formed gasket of cork or paper would **not** be available for a head gasket.
- Discuss the two types of sealers used for formed-in-place gaskets—RTV sealers and anaerobic sealers. Explain the factors that must be considered when deciding which sealer to use, and give examples of instances where each is used.
- Emphasize the necessity and importance of checking the vehicle manufacturer's recommendations about gasket replacement, and stress to students the importance of following the vehicle manufacturer's recommendations regarding gasket selection and installation.
- Discuss with students the general guidelines for replacing gaskets and the guidelines for replacing formed and formed-in-place gaskets given in Student Supplement 1.
- Have students complete Assignment Sheet 1, "Apply Guidelines for Replacing Gaskets." Discuss in class after all students have completed.

Objective 5 Replace a formed gasket

- Have students review the general guidelines for replacing gaskets and the guidelines for replacing formed gaskets given in Student Supplement 1.
- Review with students applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstrate Job Sheet 1, "Replace a Formed Gasket." Have students practice Job Sheet 1 until they are ready to take the practical test.

Objective 6 Replace a formed-in-place gasket

- Have students review the general guidelines for replacing gaskets and the guidelines for replacing formed-in-place gaskets given in Student Supplement 1.
- Discuss with students RTV sealer and anaerobic sealer, including instances when each should and should not be used.

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- Explain that the vehicle manufacturer's recommendations should be followed when selecting the type of gasket material for a specific application. Also give instances when a formed gasket can be replaced with a formed-in-place gasket.

- Review with students applicable safety rules and precautions and the guidelines given in the job-sheet introduction.

- Demonstrate Job Sheet 2, "Replace a Formed-in-Place Gasket." Have students practice Job Sheet 2 until they are ready to take the practical test.

Objective 7 Cut a gasket

- Have students review the information about gasket materials given in Student Supplement 1. Discuss the gasket materials that are available which can be used to make user-cut gaskets.

- Discuss the importance of gasket material selection and of referring to the vehicle manufacturer's recommendations.

- Review with students applicable safety rules and precautions and the guidelines given in the job-sheet introduction.

- Demonstrate the different methods of cutting a gasket. Also demonstrate the proper use of the tools used with each method. Explain when each of the methods should and should not be used.

- Have students practice Job Sheet 3, "Cut a Gasket," until they are ready to take the practical test.

Objective 8 Recall types of automotive seals and their descriptions

- Discuss with students the different types of automotive seals and their applications. Have students refer to the definition of *seal* in Objective 1, and compare the functions of a seal to the functions of a gasket.

- Display a variety of seals, and have students identify the seals as ring, rope, or lip-type.

- Give students examples of when each is used.

Objective 9 Replace a seal

- Show students examples of some of the special tools that are used to remove and install seals. Explain that in some instances a special tool must be used in order to properly install a seal and that the vehicle manufacturer will specify the tool.

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- Explain applications for using the different types of seals.
- Stress to students the importance of selecting the correct seal of the correct size. Explain to students that they should refer to the vehicle manufacturer's recommendations for seal selection and installation.
- Demonstrate the different tools that are used to remove and install seals.
- Review with students applicable safety rules and precautions and the guidelines given in the job-sheet introduction.
- Demonstration Job Sheet 4, "Replace a Seal." Have students practice Job Sheet 4 until they are ready to take the practical test.

Unit summary activities

- Discuss Activity Sheet 1, "Answer Questions About Specific Seal and Gasket Applications." The purpose of this activity is to give students additional practice in finding seal and gasket information in service and professional manuals.
- Have students complete Activity Sheet 1. Discuss in class when all students have completed.
- Discuss Activity Sheet 2, "Report on Sealers and Gasket Compounds." The purpose of this activity is to give students an awareness of the new seal and gasket materials that have recently been developed. Keep this in mind when discussing this assignment.

EVALUATION

- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Reteach and retest as required.
- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- *Chilton's Auto Repair Manual 1985: Domestic and Canadian Cars from 1978 through 1985.* Radnor, Pennsylvania: Chilton Book Company, 1984.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill Book Company, 1985.

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- Duffy, James E. *Modern Automotive Mechanics*. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- Gilles, Tim. *Engine Mechanics: Diagnosis and Repair*. Boston, Massachusetts: Breton Publishers, 1986.
- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon*. Centerline, Michigan: Chrysler Corporation, 1985.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair*. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1984.

1261

PRETEST ANSWERS

REMOVE AND REPLACE SEALS AND GASKETS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 10
2	18, 22
3	2, 12, 19
4	4, 5, 7, 15, 16, 20
5	7, 9
6	5, 8, 20
7	11, 13
8	3, 17, 21
9	6, 14

ANSWER KEY

1. c
2. b
3. d
4. a
5. a
6. c
7. b
8. c
9. b
10. c
11. c
12. c
13. d
14. a
15. d
16. a
17. b
18. d
19. a
20. d
21. a
22. d

1202

PRETEST

REMOVE AND REPLACE SEALS AND GASKETS

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which of the following is the best definition of *gasket*?

   a. Specialized gasoline filter
   b. Thin, rigid device used to align fasteners when joining parts
   c. Thin, compressible material placed between surfaces of nonmoving parts to prevent leakage
   d. Substance, usually liquid, used to hold parts together

2. Which of the following is **not** a type of automotive gasket?

   a. Formed
   b. Reformable
   c. Formed-in-place
   d. User-formed

3. Which of the following is **not** a type of seal?

   a. Ring seal — Shaped rubber or neoprene ring
   b. Rope (packing) seal — Braided fabric
   c. Lip-type seal — Circular device with rubber- or neoprene-coated metal housing; may be spring reinforced
   d. Liquid seal — Liquid substance that dries in place

4. Technician A and Technician B are discussing gaskets. Technician A says that before installing a gasket, the old gasket material must be removed from the parts. Technician B says that fasteners that go through gaskets should be tightened to torque to fully compress the gasket and then be backed off one-quarter turn to allow the gasket to spring back.

   Who is right?

   a. Technician A
   b. Technician B
   c. Both A and B
   d. Neither A nor B

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5. Anaerobic sealer should be used

   a. On tight-fitting, thick parts that are smooth and flat
   b. Instead of solid-material gaskets if the joint will be exposed to fuel
   c. On both sides of a head gasket for overhead cam engines
   d. On thin flanges or parts with uneven surfaces

6. Technician A and Technician B are discussing seals. Technician A says that the inside diameter of a ring seal must be the correct size. Technician B says that the outside diameter of a ring seal must be the correct size.

   Who is right?

   a. Technician A
   b. Technician B
   c. Both A and B
   d. Neither A nor B

7. Which of the following is **not** a good practice for the installation of a formed gasket?

   a. Put the gasket in place and check for proper fit and alignment
   b. For high-mileage vehicles, use the next thicker size of gasket to allow for wear
   c. Inspect the mating surfaces for dents and scratches
   d. Inspect the new gasket for damage and check to see that all required openings are free of material

8. Formed-in-place gaskets such as RTV should be applied so that the bead is

   a. Thickest around holes
   b. Thickest at bends and other high-pressure areas
   c. An even thickness on one surface
   d. The same thickness on both mating surfaces

9. When inspecting a gasket prior to installation, such as a head gasket, you should make sure that

   a. All fastener holes are free of material
   b. All required holes and openings are free of material
   c. Only required fastener holes are free of material
   d. Bolt holes are no more than 1/64 inch wider than the corresponding fasteners

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10. Which of the following is the best definition for *seal*?

    a. Completely enclosed and airtight
    b. Electrical protection device that breaks an electrical circuit when overloaded
    c. Material shaped to leakproof moving parts
    d. Thin, compressible material placed between surfaces of nonmoving parts to prevent leakage

11. A service specialist will normally cut a gasket for an installation only if

    a. There is little else to do in the shop and the materials are available
    b. The cost of a formed gasket is more than $10
    c. The gasket is simple and made from common gasket materials
    d. The installation is not suitable for formed-in-place gaskets or formed gaskets

12. Which of the following statements best describes a formed-in-place gasket?

    a. Gasket manufactured from soft rubber materials that stretch to the required size and shape
    b. Gasket manufactured to fit the shape and hole arrangement of the parts it seals
    c. Gasket user-made by applying special sealers to parts
    d. Gasket user-cut from gasket material to fit the parts it seals

13. When choosing material to use in cutting a gasket, the specialist should consider requirements such as

    a. Thickness of the gasket
    b. Type of material needed for installation
    c. Use of sealers and other treatments
    d. All of the above

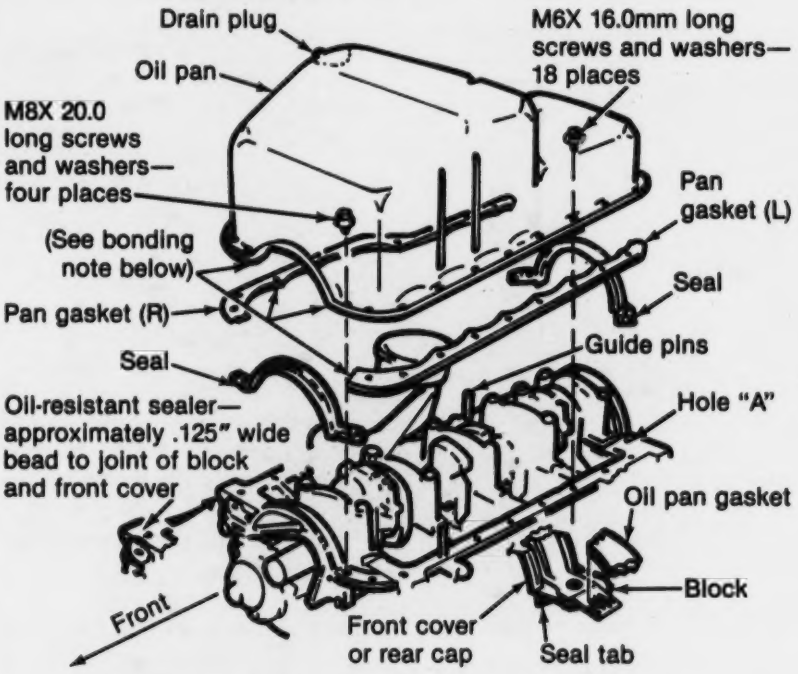
14. If a seal is found to be leaking, the service specialist should

    a. Replace the seal
    b. Tighten the installation
    c. Lower the fluid level or pressure
    d. Any of the above

1205

NOTE: Items 15 and 16 apply to the illustration below.

Installation of the oil pan on a Ford 2.3L engine



1. Apply gasket adhesive evenly to oil pan flange and to pan side gaskets. Allow adhesive to dry past wet stage, then install gaskets to oil pan.
2. Apply sealer to joint of block and front cover. Install seals to front cover and rear bearing cap and press seal tabs firmly into block. *Be sure to install the rear seal before the rear main bearing cap sealer has cured.*
3. Position 2 guide pins and install the oil pan. Secure the pan with the four M8 bolts shown above.
4. Remove the guide pins and install and torque the eighteen M6 bolts beginning at hole "A" and working clockwise around the pan.

Used with permission of Ford Motor Company.

15. Which of the following statements about the oil pan installation shown above is correct?

    a. The pan gasket is placed between the seal and the block
    b. The left and right halves of the oil pan gasket are interchangeable
    c. Only one gasket, which is cut in half for installation purposes, is used
    d. The adhesive should be allowed to dry slightly before installing the gaskets to the oil pan

1206

16. Technician A says the correct procedure for installing the pan gasket is to apply gasket adhesive to the pan, allow the adhesive to set partially, and put the gasket on the pan.

Technician B says the correct procedure is to apply sealant to the pan and gasket, allow the sealant to set partially, and put the gasket on the pan.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

17. Which of the following seals may be spring reinforced?

a. Ring seal
b. Lip-type seal
c. Square-ring seal
d. O-ring seal

18. Which of the following is the best definition of *compress*?

a. To tighten two flat parts together
b. To cut a gasket to a required shape
c. To leakproof moving parts
d. To reduce in size or volume by squeezing

19. A gasket manufactured to fit the shape and hole arrangement of the parts it seals is called a

a. Formed gasket
b. Formed-in-place gasket
c. User-formed gasket
d. None of the above

20. When joining parts separated by a formed-in-place gasket, you should tighten fasteners

a. Ten percent more than the torque specified for formed gaskets to ensure a proper seal
b. To specified torque and then back one-quarter turn
c. Until gasket material is squeezed evenly and completely to the edge of the parts
d. To specified torque

1207

21. Which of the following statements best describes a *ring seal*?

a. Shaped rubber or neoprene ring
b. Circular device with rubber- or neoprene-coated metal housing
c. Braided fabric partially formed in a circular shape
d. None of the above

22. Which of the following is the best definition of *sealer*?

a. Material shaped to leakproof moving parts
b. Thin, compressible material placed between surfaces of nonmoving parts to prevent leakage
c. Rubber ring placed between a moving surface and a nonmoving surface to prevent leakage
d. Sticky liquid substance either used with gaskets or to make certain types of gaskets

1208

INFORMATION SHEET

REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 1

Recall definitions of *seal* and *gasket*

Gasket — Thin, compressible material placed between surfaces of nonmoving parts to prevent leakage

NOTE: Gaskets compress enough to fill in the uneven areas of the joined surfaces. They prevent substances inside the assembly from leaking out while at the same time keeping dirt, water, and other unwanted materials from getting in.

Seal — Material shaped to leakproof moving parts

Seals and Sealers

The terms used to describe vehicle construction can sometimes be confusing. Some terms have more than one meaning and many terms are not used with much precision in the trade. *Seal* and *sealer* are such words. The word *seal* has several meanings in automotive service. The definition given above is for an object, generally made of rubber, that is used to leakproof a moving part. An example is the camshaft where it extends from the block to the camshaft gear, or the fan shaft where it extends from the water pump. These seals work to prevent oil and coolant respectively from leaking around the shafts and to keep dirt, water, and other contaminants out.

The term *seal* also is used to name the joint where a gasket or seal functions or simply where two parts join tightly enough to prevent leakage.

Finally, the term is applied to the action of creating such a joint—a gasket "seals" the water pump to the engine.

A *sealer* is a thick, usually sticky, liquid used with fasteners, hoses, and gaskets to make materials less penetrable by gases and liquids. A sealer alone can sometimes join parts, or a sealer can be used with a gasket—some gaskets required the use of a sealer. Many newer automotive designs use *formed-in-place* gaskets, which are made by applying special sealers that cure to a rubbery material, thus forming a gasket between parts.

1209

OBJECTIVE 2

Recognize definitions of terms associated with automotive seals and gaskets

Alignment — Positioning of two or more parts to achieve a desired relationship

Compress — To reduce in size or volume by squeezing

Cure — To complete a chemical process in which a substance takes a finished form

Hand-start — To begin the installation of a fastener by hand before using a tool

Reinforced — Strengthened through the use of additional material or structural support

Sealer — Sticky liquid substance either used with gaskets or to make certain types of gaskets

NOTE: On many newer vehicles special sealers are used to make formed-in-place gaskets for some parts. Usually in a tube, these go on as a paste and then cure to a rubber-like texture or plastic. Two types are the room-temperature-vulcanizing (RTV) and anaerobic sealers, which cure in the absence of air.

1210

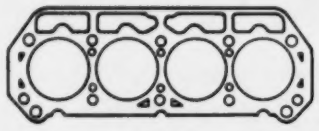
OBJECTIVE 3

Recall types of automotive gaskets and their descriptions

Formed — Gasket manufactured to fit the shape and hole arrangement of the parts it seals (Figure 1)

EXAMPLE:

FIGURE 1



Head gasket

Formed-in-place — Gasket user-made by applying special sealer to parts

EXAMPLE: Silicone rubber (room-temperature-vulcanizing [RTV] sealer)

User-formed — Gasket user-cut from gasket material to fit shape of parts it seals

NOTE: User-formed gaskets may be cut form different materials such as cork, paper, or others, depending upon the specific use and location of the gasket. This type of gasket is especially useful for simple, hard-to-obtain gaskets.

EXAMPLE: Thermostat gasket for '37 Studebaker

Gasket Materials

Gaskets come in a variety of materials for different applications. Some of the more common materials include fiber, natural rubber, synthetic rubber, cork, paper, cardboard, or thin metals. The choice of material will depend on exposure to high temperatures, pressures, and chemicals such as exhaust gases or fuel. The material must be able to withstand the conditions under which the gasket is used. Gasket materials may be chemically treated to make them more suitable for certain uses, such as more resistant to water. The specific application of the gasket may also require the use of a sealer.

1211

OBJECTIVE 8

Recall types of automotive seals and their descriptions

Ring seal — Shaped rubber or neoprene ring (Figure 2)

EXAMPLE:

FIGURE 2

Rope (packing) seal — Braided fabric (Figure 3)

NOTE: This seal may be available as an unformed rope that is to be cut to the correct length. However, a rope seal is usually sold as a set of partially preformed sections.

EXAMPLE:

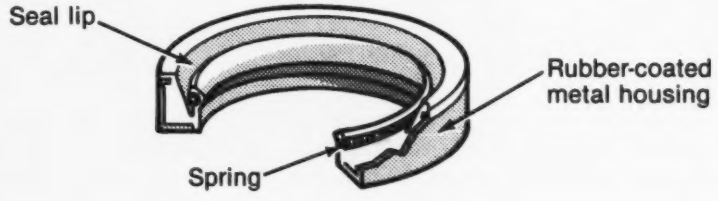
FIGURE 3

Lip-type seal — Circular device with rubber- or neoprene-coated metal housing; may be spring reinforced (Figure 4)

NOTE: A lip-type seal may be made of one or two pieces.

EXAMPLE:

FIGURE 4



1212

REMOVE AND REPLACE SEALS AND GASKETS

SUPPLEMENT 1

Gasket Guidelines

Gaskets are designed for many different situations. When replacing a gasket, the service specialist must know how to select the correct type of gasket and must be able to properly install the replacement gasket. In order to do this, the service specialist must be familiar with the different gasket materials and their uses, the different factors to consider when selecting the replacement gasket, and the guidelines that should be followed when installing the new gasket.

GASKET MATERIALS

Gasket materials vary from the embossed steel used for head gaskets to the paper used for timing cover and fuel pump gaskets. The chemical sealer gaskets have become increasingly popular and are being used now in places where paper and cork gaskets were used. Other than retorqueable head gaskets, paper gaskets are generally the only gaskets that require a sealer unless otherwise recommended by the manufacturer.

The automotive service specialist should be familiar with the various materials used for automotive gaskets. Some of the more common materials and their applications are listed below.

Paper gaskets are used on water outlets, water pumps, timing covers, fuel pumps, and some carburetors.

Neoprene (artificial rubber) gaskets are reusable. They are used with valve covers, which are periodically removed for adjustment.

Cork gaskets are commonly used as valve cover, transmission, and engine-oil-pan gaskets. They are sometimes mixed with neoprene. The use of cork gaskets is limited because of their shrinkage and brittleness.

Steel gaskets are used in high-temperature areas—some head gaskets are made of steel. Steel gaskets are used *only* with cast iron heads and blocks, never with aluminum.

Asbestos/combination gaskets are made with asbestos or other heat-resistant material. These gaskets are used in high-temperature areas; a carburetor-to-manifold gasket may be made with asbestos.

Teflon gaskets are used in high-temperature areas.

Silicone sealer is used to make formed-in-place gaskets. This is a room-temperature-vulcanizing (RTV) sealer, and it is not used in high-temperature areas.

Anaerobic sealers are used to make formed-in-place gaskets where heat or harsh chemicals are present. These sealers cure without air—they actually begin to cure once mating surfaces are put together, allowing time to properly position the mating surfaces.

REPLACING GASKETS

Gaskets and seals both function to prevent leaks. Gaskets leakproof nonmoving parts, seals moving parts. The automotive specialist has a choice of two types of gaskets: the *formed* and the *formed-in-place*. Consider several factors in selecting the correct type of gasket to use. Some of the questions to ask are:

- Is the vehicle equipped with oxygen sensors?
- Is the gasket going to be placed near high temperatures?
- Will the gasket be near electronic sensors?
- Does the location of the parts in the engine make it difficult to apply the formed-in-place gasket?

Firsthand observation will answer some of these questions. The vehicle service manual and the gasket manufacturers' instructions will answer the rest. Some rules for installation apply specifically to formed-in-place gaskets. But other rules apply generally to the installation of either type of gasket.

General guidelines for replacing gaskets

- Select the correct type and size of gasket made of the correct material.

- Remove all the old gasket. Scrape or brush with a wire brush gently to avoid damage to the part. The smallest nick or dent can result in an imperfect seal, and then leakage can occur. Finish cleaning the surfaces to be sealed by wiping clean and dry with a shop cloth and solvent.

- Use a chemical gasket remover for aluminum components. Do **not** scrape, and do **not** use a wire brush.

► WARNING ◄

Spray cleaners can damage skin and eyes. Always follow the safey instructions on container label.

- Hand-start fasteners then tighten in the recommended torque sequence to the correct torque. Do **not** overtighten fasteners. Overtightening can damage metal parts and break the formed gasket or can squeeze the formed-in-place gasket sealer away from the mating surfaces.

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- Complete gasket replacements by checking for leaks. If a gasket leaks, it must be replaced and the fasteners retightened to the correct torque.

Guidelines for using formed gaskets

- With the exception of neoprene gaskets, gaskets cannot be reused. As a gasket is installed and the mating surfaces are tightened together, the gasket is compressed. The gasket will not return to its original thickness when removed. Therefore, it cannot be reused because it will not compress and seal properly.

- Store gaskets properly. They should be stored flat in their packages away from extreme temperatures and humidity.

- Always inspect gaskets carefully before installing them. Be sure they are free of dents, cracks, bends, or debris. A badly bent gasket cannot be corrected without damaging the gasket.

- Handle gaskets carefully. Do **not** force a gasket to fit. If it becomes cracked or torn, it can no longer be used and should be thrown away.

Guidelines for using formed-in-place gaskets

Use of the formed-in-place gasket is increasing. Installing a formed-in-place gasket eliminates buying or making a gasket of a specific size or shape. The chemical sealers used to make formed-in-place gaskets allow the automotive service specialist to fit a gasket to almost any size or shape parts.

Two types of sealers are the RTV or silicone rubber and the anaerobic sealer. RTV sealers form a rubber-like gasket and are used on thin, flexible flanges. Anaerobic sealers harden in the absence of air and set up like a plastic. They make a formed-in-place gasket for thick, tight-fitting, smooth, and flat parts.

Rules that apply specifically to the installation of formed-in-place gaskets are listed below and on the following page.

- Make sure that the vehicle manufacturer allows the use of a formed-in-place gasket for the application.

- Check the RTV or anaerobic sealer to make sure it is appropriate for the specific application. Use sealer-made gaskets for almost every part except those in high-temperature and fuel areas.

- Some sealers used for making formed-in-place gaskets produce vapors that interfere with the operation of electronic sensors on the vehicle, so be sure to check vehicle manufacturer's service manual.

- Use a low-volatile RTV on vehicles having oxygen sensors and use it sparingly. Vehicles with computer-controlled ignitions have oxygen sensors.
- Follow the sealer manufacturer's instructions about the time to wait before tightening fasteners. The curing time for RTV sealers is about 10 minutes, for anaerobic sealers about 15 minutes.
- Always use the bead size specified by the sealer manufacturer.

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ASSIGNMENT SHEET 1

REMOVE AND REPLACE COMMON FASTENERS

OBJECTIVE 4

Apply guidelines for replacing gaskets

Name _____ Score _____

INTRODUCTION

Gaskets are designed to work well in specific situations. For example, for a gasket to work it must fit the shapes of the mating surfaces, allow for pins and fasteners, be made of a material that will withstand the conditions of the installation, and meet other requirements. The service specialist must consider such factors when replacing a gasket. Where the specialist has options in choosing gaskets, he or she must be able to determine which of the options is best suited for a particular situation. Finally, after choosing the correct gasket, the specialist must make sure that guidelines for making the installation are followed. This assignment sheet will give you practice in applying guidelines to specific applications.

PART A DIRECTIONS

Study Student Supplement 1, "Gasket Guidelines," and then read the following situations and questions. Write your answers in the spaces provided.

1. What are the two types of sealers used for formed-in-place gaskets?

   _____

   _____

2. Should the location of the gasket be considered when selecting a replacement gasket?

   _____

3. You need to replace a gasket that is located near the engine where the temperature is very high. Would RTV be suitable for this application? Why or why not?

   _____

   _____

4. When deciding on a suitable replacement gasket, what three characteristics should be considered?

   _____

5. Technician A says that a chisel and hammer may sometimes be used to remove an old gasket and that any dents or scratches left by the chisel will be filled by the gasket. Technician B says that all the old gasket must be removed, but must be removed in a manner that avoids damaging the parts. Which technician is correct? Why?

_____

_____

6. You need to choose a sealing material for a valve cover. The valve cover requires periodic removal so valves can be adjusted. What type of gasket would be suitable for this application?

_____

7. What should be used to remove old gasket material from aluminum components?

_____

8. The carburetor top gasket is leaking. Technician A says the problem can be corrected by using a thin layer of RTV sealer on the gasket and then retightening the fasteners. Technician B says that replacing the top gasket and retightening fasteners is the best way to seal the leak. Who is right?

_____

9. How much time should you allow after applying RTV sealer before tightening the fasteners?

_____

_____

10. How long should you wait before tightening the bolts on a pan after applying anaerobic sealer?

_____

_____

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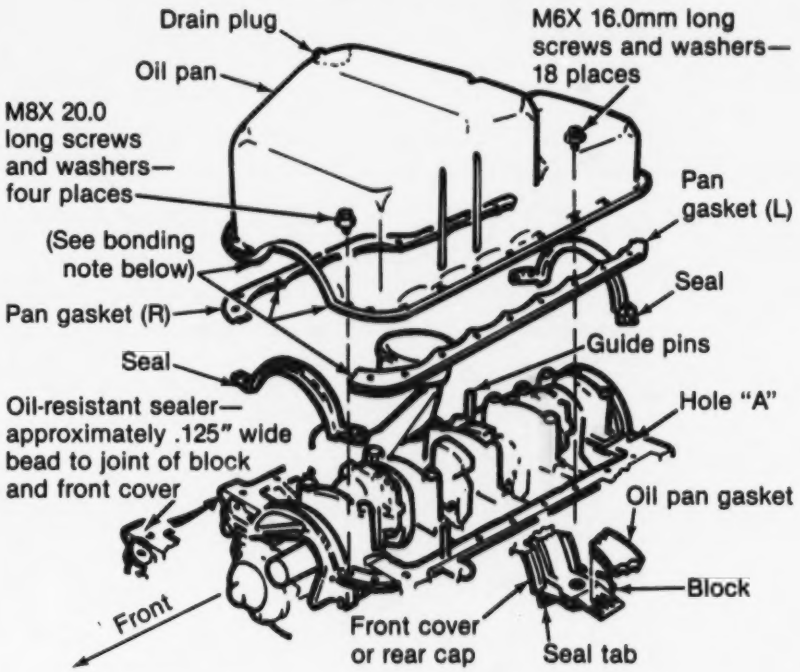
PART B
DIRECTIONS

Study the following illustration, then answer the questions below and on the next page. Write your answers in the spaces provided or write an "X" in the blanks before the correct answers.

Installation of the oil pan on a Ford 2.3L engine



1. Apply gasket adhesive evenly to oil pan flange and to pan side gaskets. Allow adhesive to dry past wet stage, then install gaskets to oil pan.
2. Apply sealer to joint of block and front cover. Install seals to front cover and rear bearing cap and press seal tabs firmly into block. *Be sure to install the rear seal before the rear main bearing cap sealer has cured.*
3. Position 2 guide pins and install the oil pan. Secure the pan with the four M8 bolts shown above.
4. Remove the guide pins and install and torque the eighteen M6 bolts beginning at hole "A" and working clockwise around the pan.

Used with permission of Ford Motor Company.

1. Is the end of the pan gasket placed between the seal and the block or the seal and the pan?

_____

2. Are the left and right halves of the oil pan gasket interchangeable?

_____

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3. Which of the following is the correct procedure for installing the pan gasket?

_____a. Apply sealant to the pan and gasket, allow the sealant to set partially, and put the gasket on the pan

_____b. Apply gasket adhesive to the pan and gasket, allow the adhesive to set partially, and put the gasket on the pan

_____c. Apply sealant to the block and gasket, allow the sealant to set but not cure, and put the gasket on the block

_____d. Apply gasket adhesive to the pan, put the gasket on the pan before the adhesive cures, put additional adhesive on the gasket, and install pan

1220

ASSIGNMENT ANSWERS

REMOVE AND REPLACE SEALS AND GASKETS

ASSIGNMENT SHEET 1

PART A

1. Anaerobic sealer and room-temperature-vulcanizing (RTV) sealer
2. Yes
3. No; RTV should not be used in high-temperature areas
4. Type, size, and material
5. Technician B; a small nick or dent could result in an imperfect seal, and leakage could occur
6. Formed neoprene gasket
7. Chemical gasket remover
8. Technician B
9. Generally about 10 minutes, but always follow seal manufacturer's instructions
10. Generally about 15 minutes, but always follow seal manufacturer's instructions

PART B

1. Seal and pan
2. No
3. b

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REMOVE AND REPLACE SEALS AND GASKETS

ACTIVITY SHEET 1

Answer questions about specific seal and gasket applications

Name _____

INTRODUCTION

All vehicles use various seals and gaskets to maintain fluid integrity. These seals and gaskets are of different composition, ranging from paper to a paste-like material that conforms to any surface. Choosing the proper gasket or seal is as important as its physical replacement. The replacement seal or gasket must be of the right type and composition in order to do the job and be durable. It is therefore very important that the service specialist research and compare seal and gasket types in order to select the proper seal or gasket.

DIRECTIONS

Read the following situations and answer the questions with each. Be prepared to make recommendations as to the type or composition of the seal or gasket required to perform the proper repair according to specifications.

SITUATION A

A customer brings in a 1986 Chevrolet Celebrity to your shop for lubrication service and complains of leakage under the vehicle. Upon inspection you find that the standard transmission fluid is low, the engine oil is low, and the coolant is low. Upon further inspection you find there is a rear engine oil leak, there are axle seals leaking, and there is a leak at the water pump and at the thermostat housing.

1. What type of seals would be needed to repair the engine oil leak?

   _____

2. What type of sealing material would you use on the water pump? Would it be the same for the thermostat housing?

   _____

3. Is there a formed gasket used on the transmission?

   _____

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SITUATION B

A 1979 Ford LTD with a 302 V8 engine with a leak at the valve cover gasket has been brought to your shop. The front wheel disc rotor has grease streaks on it. The bearing is also noisy, and the inner seal has been leaking.

1. What type of gasket would you use to seal the valve cover?

   _____

2. What kind of seal is used in the front hub?

   _____

SITUATION C

A 1986 Buick with a 3.8-liter V6 engine and a 200 THM is in the shop and needs the oil pan leak repaired. The transmission leaks and needs to be resealed.

1. What type of sealer is used on the engine oil pan?

   _____

2. What type of sealer would be used on the transmission oil pan?

   _____

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REMOVE AND REPLACE SEALS AND GASKETS

ACTIVITY SHEET 2

Report on sealers and gasket compounds

Name _____

INTRODUCTION

Modern science and technology are constantly introducing new concepts to automotive design and construction. Such developments often create new demands on the materials used in manufacturing vehicles. Science usually responds to these demands with new materials and techniques. For example, a few years ago most gaskets were made of rubber, paper, cork, and metals. Today, many formed gaskets have been replaced by formed-in-place gaskets made from special gasket compounds. Each of these compounds has a chemical formula that meets the specific requirements for a particular application. You can expect such developments to continue throughout your automotive service career. You will, therefore, need to keep current on the latest developments in gasket compounds and sealers.

DIRECTIONS

You will make a short report on a sealer, a gasket compound, or a new development in seal and gasket materials. The report may be made orally for the class or in writing for your instructor. You may choose a material or be assigned one by your instructor. You should describe the advantages and disadvantages of the materials as well as decribe their uses.

1284

ACTIVITY ANSWERS

REMOVE AND REPLACE SEALS AND GASKETS

ACTIVITY SHEET 1

SITUATION A

1. Lip-type seals
2. Paper gasket; yes
3. No; anaerobic sealer only

SITUATION B

1. Neoprene gasket
2. Lip-type seal

SITUATION C

1. Proper low-volatile RTV used sparingly
2. Anaerobic sealer

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JOB SHEET 1	REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 5

Replace a formed gasket

INTRODUCTION

Formed gaskets are manufactured to fit a specific part. They may be made of paper, rubber, cork, thin metal, or other substances that will compress slightly between parts to prevent leakage of gases or fluids. Formed gaskets are used frequently for applications such as head gaskets, carburetor gaskets, exhaust manifold gaskets, and thermostat housing gaskets.

Formed gaskets that may have to be altered slightly for a specific application are also available. For example, a hole for a bolt may have to be punched out for one use of a gasket while not punched out for another application.

Certain guidelines, in addition to those explained in Student Supplement 1, "Gasket Guidelines," should be followed when replacing formed gaskets, and these are listed below.

- Inspect the mating surfaces to be sure that no dents or deep scratches will prevent an adequate seal.
- See vehicle manufacturer's recommendations when selecting new gasket.
- Inspect the new gasket for damage, and check to see that all required openings are free of material.
- Put the gasket in place on the part, and check for proper fit and alignment.
- Use the recommended sealer when required.
- Follow the vehicle or gasket manufacturer's instructions for proper installation, including any follow-up procedures, such as retightening after a certain interval.

This job sheet will give you practice in replacing a formed gasket.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped and to gasket manufacturer's instructions for gasket selection and installation.

1226

JOB SHEET 2

REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 6

Replace a formed-in-place gasket

INTRODUCTION

The use of formed-in-place gaskets is becoming more common both in the types of applications and the number of vehicle models using such applications. They are increasing in popularity because they eliminate the need of buying or making a gasket for a specific application. However, the installation of formed-in-place gaskets requires skills other than those used to install formed gaskets.

There are two basic types of formed-in-place gasket materials. One is silicone-based and is commonly referred to as *RTV sealer*, which stands for room temperature vulcanizing. An RTV sealer normally comes in a tube and has a creamy texture. Once applied, moisture in the air causes it to vulcanize, or turn rubbery. Thus, the service specialist is able to apply RTV sealer on a surface that requires a gasket, following the shape of the part, encircling fastener holes, and leaving an even bead of sealer. The sealer begins to set up immediately, and when the parts are joined and the sealer has cured completely, the sealer will have formed a rubbery gasket.

The second type of formed-in-place gasket material is *anaerobic sealer*. *Anaerobic* means "without air." Anaerobic sealers cure to a plastic-like gasket without air exposure. They should be used on tight-fitting, thick parts that are smooth and flat. Use on thin flanges or parts with uneven surfaces will not allow proper curing.

The sealers used to make formed-in-place gaskets are formulated for different purposes. Often they are color-coded to help identify that purpose. Thus, RTV may be black, clear, blue, or some other color to indicate its purpose. The service specialist must be careful to use the correct type of formed-in-place gasket. More information about RTV and anaerobic sealers is given in Student Supplement 1, "Gasket Guidelines."

Some skills are common to both types of gasket replacements. In both cases the mating surfaces should be carefully cleaned and inspected. Also the instructions provided by the gasket manufacturer should be followed. Some general guidelines are given in Student Supplement 1, and some more specific guidelines are listed below and on the following page.

- RTV sealer is usually used on surfaces that flex, such as valve covers. Anaerobic sealer should not be used on parts that flex.

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- Be sure the type of sealer used to make the formed-in-place gasket is appropriate for the intended application. Some of these materials produce vapors that interfere with electronic sensor operation and should not be used near sensors. Whether or not the gasket material will be exposed to high temperatures, chemicals, and high pressures also should be considered. Always check the vehicle manufacturer's service manual.
- Check the date of formed-in-place gasket materials; most have an expiration date printed on the package and are not usable after that date.
- When applying the gasket material, make the bead even and complete, making sure that all bolt and stud holes are completely surrounded.
- Follow the sealer manufacturer's instructions about the time to wait before tightening fasteners.
- Tighten fasteners evenly in the correct sequence and to the correct torque. Be careful not to overtighten the fasteners as this may squeeze the gasket material completely away from the mating surfaces.

This job sheet will give you practice in replacing a formed-in-place gasket.

EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped and to gasket-material manufacturer's instructions for gasket-material selection and installation.

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JOB SHEET 3

REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 7

Cut a gasket

INTRODUCTION

In some instances the service specialist can make a gasket from materials such as gasket paper or rubber. Some manufacturers sell tool sets for cutting the holes in user-cut gaskets. Cutting a gasket can be a convenient procedure in that simple gaskets can be made rather than purchased for a specific application. Occasionally, cutting a gasket may be the alternative the service specialist must take to replace a gasket that can no longer be purchased. This procedure can sometimes save time and money for both the service specialist and the customer.

Because of special needs in specific applications, a user-cut gasket is not recommended in all cases. For example, the required gasket material may not be available or, if available, may be too difficult to work with. A very detailed gasket may require too much time to properly make. Thus, this procedure is generally used only for simple gaskets made of common gasket materials, such as the paper or rubber gaskets that may be found on many thermostat housings or water pumps.

General replacement guidelines are given in Student Supplement 1, "Gasket Guidelines," but the service specialist who chooses to a cut a gasket must also observe the following guidelines.

- Be sure that the material used meets all the specifications of the original gasket, including type of material, thickness, any special treatment, and other considerations.
- If using a hammer to tap the outline of the gasket, use a small ball-peen hammer and be sure to tap lightly enough to avoid damaging parts but firmly enough to achieve the gasket outline.
- Use care in cutting to avoid tearing the gasket material. Cut smaller holes first using a hole cutter. Then use a razor blade or a pair of scissors to cut the perimeter of the gasket.
- Check the fit of the new gasket before installing it, making certain that the size and shape are correct.

This job sheet will give you practice in cutting a gasket.

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EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Your instructor will demonstrate the procedure used to cut a gasket.

1230

JOB SHEET 4

REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 9

Replace a seal

INTRODUCTION

Seals prevent leaks between moving and nonmoving parts. They come in a variety of designs to suit their many applications. To be effective a seal must be flexible enough to conform to the shape of a part. But the seal must offer enough pressure to prevent leakage of lubricants or fluids and to prevent their contamination by foreign material. Any time a leaking seal is discovered, it should be replaced.

Vehicle manufacturers often design special tools for use in the removal and installation of seals. In some cases substitutes can be found for these tools; however, the procedures are still applicable, and the service specialist must be sure that the purposes of the special tools are met.

Many seals are specifically designed for a particular make and model of vehicle. Others, such as ring seals, may be usable on a variety of vehicles requiring a certain shape and size of ring seal. Still other seals, such as rope or packing seals, may be usable in almost any vehicle that uses that type of seal.

When choosing a proper seal, the service specialist must be concerned not only with the inside diameter—the portion that fits onto the shaft—but also with outside diameter and with thickness. Proper dimensions are required for correct fit.

Some general guidelines for replacing seals are

- Remove the old seal carefully. Take care when prying out the old seal not to scratch the housing. Sometimes you may need a special puller.
- Inspect shaft for wear and burrs. File off any burrs that could cut the new seal. Excessively deep grooves worn by seals may need repair before replacing seal; if such grooves are evident, check with vehicle manufacturer's service manual for instructions. Use a crocus cloth to polish the surface on which the seal rides.
- Contaminated oil and other fluids may cause seal damage, so check the fluid by feeling fluid between two fingers. If it is gritty, it is probably the reason the seal is damaged; check vehicle manufacturer's service manual regarding fluid replacement service.

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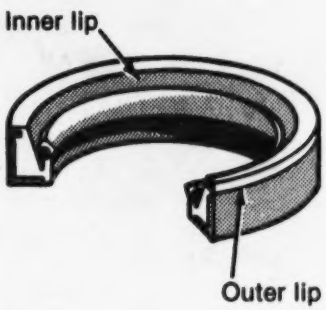
- Check the new seal size. When replacing ring seals and lip-type seals, compare the old seal to the new seal by holding them next to each other. The inside and outside diameters must be the same. However, the old seal may be slightly distorted or its interior worn excessively.

- Install the new seal correctly. Apply the approved sealer to the outside of the seal housing; however, some manufacturers advise against applying sealing material, so be sure to check manufacturer's specifications. Coat inner lip of the seal with system fluid (see Figure 1). Do not coat outer lip; most manufacturers advise against coating outer lip of the seal. If installing a lip-type seal, always follow the manufacturer's directions regarding the direction the seal should face.

FIGURE 1



- Use a seal installer when installing a lip-type seal. This will prevent the seal from being scratched or distorted and will assure that the seal is set at its proper depth.

- When installing a rope seal, make sure it is firmly seated and compacted (depending on composition of the seal) in the groove according to seal manufacturer's directions. Check vehicle manufacturer's service manual for trimming specifications.

- After installing a ring seal, smooth seal with fingers to make sure seal is not twisted.

- Check to see that the seal is squarely and fully seated in its bore. The manufacturer may specify how deep the seal must be installed.

- Check and adjust fluid level after seal installation, and check for leaks.

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EQUIPMENT AND MATERIALS

As required by procedure

PROCEDURE

NOTE: Refer to vehicle manufacturer's service manual for make and model as equipped and to seal manufacturer's instructions for seal selection and installation.

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PRACTICAL TEST

REMOVE AND REPLACE SEALS AND GASKETS

JOB SHEET 1

Replace a formed gasket

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used reference materials correctly to select proper replacement gasket.	_____	_____
3. Prepared mating surfaces properly.	_____	_____
4. Installed gasket following procedure given in vehicle manufacturer's service manual.	_____	_____
5. Checked for leaks and made necessary corrections.	_____	_____
6. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1234

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

REMOVE AND REPLACE SEALS AND GASKETS

JOB SHEET 2

Replace a formed-in-place gasket

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used reference materials correctly to select proper formed-in-place gasket material.	_____	_____
3. Prepared mating surfaces properly.	_____	_____
4. Applied gasket material following procedure given in vehicle manufacturer's service manual.	_____	_____
5. Completed installation following procedure given in vehicle manufacturer's service manual.	_____	_____
6. Check for leaks and made necessary corrections.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

REMOVE AND REPLACE SEALS AND GASKETS

JOB SHEET 3

Cut a gasket

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used reference materials correctly to select proper gasket material.	_____	_____
3. Prepared mating surfaces properly.	_____	_____
4. Cut gasket material following procedure demonstrated by instructor.	_____	_____
5. Used correct tools to cut gasket material.	_____	_____
6. Checked gasket for proper fit and made necessary corrections.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

1233

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

REMOVE AND REPLACE SEALS AND GASKETS

JOB SHEET 4

Replace a seal

Student's name: _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Used reference materials correctly to select proper replacement seal.	_____	_____
3. Properly prepared surfaces to be sealed.	_____	_____
4. Installed seal following procedure given in vehicle manufacturer's service manual.	_____	_____
5. Used correct tools for seal removal and installation.	_____	_____
6. Checked seal installation.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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WRITTEN TEST

REMOVE AND REPLACE SEALS AND GASKETS

Name _____ Score _____

OBJECTIVE 1

Write the definitions of *seal* and *gasket* in the blanks below.

a. **Seal** — _____

_____

b. **Gasket** — _____

_____

OBJECTIVE 2

Choose the definitions that best define the following terms associated with automotive seals and gaskets. Write the correct numbers in the blanks.

_____a. **Reinforced**

1. Strengthened through the use of additional material or structural support
2. Strengthened through the use of gaskets
3. Shaped to fit through the use of high-pressure forces as in the manufacturer of gaskets and seals

_____b. **Compress**

1. To tighten two flat parts together
2. To cut a gasket to a required shape
3. To reduce in size or volume by squeezing

_____c. **Hand-start**

1. To begin the installation of a fastener by hand before using a tool
2. To start an engine with a crank or similar device
3. To feed sealant into place by hand instead of through the use of tools

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_____d. **Sealer**

1. Rubber membrane used in a pump to produce pressure changes
2. Sticky liquid substance either used with gaskets or to make certain types of gaskets
3. Rubber ring placed between a moving surface and a nonmoving surface to prevent leakage

_____e. **Alignment**

1. Measured thickness of a seal or gasket
2. Positioning of two or more parts to achieve a desired relationship
3. Use of measuring devices to determine thickness requirements of a seal or gasket

_____f. **Cure**

1. To complete a chemical process in which a substance takes a finished form
2. To cut a gasket to correct size and shape
3. To prepare a shaft for the installation of a gasket

OBJECTIVE 3

List the types of automotive gaskets, and then write their descriptions. Write your answers in the blanks provided.

a. **Type** — _____

Description — _____

_____

_____

b. **Type** — _____

Description — _____

_____

_____

c. **Type** — _____

Description — _____

_____

_____

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OBJECTIVE 4

Read the following questions and situations about gasket replacement. Then write the correct answers in the blanks.

a. When replacing a gasket on an aluminum cylinder head, you notice that some of the old gasket is still stuck to the head. What is the correct way to remove this gasket material?

_____

_____

_____

b. What should be done if a gasket begins to leak?

_____

_____

_____

c. When applying a sealer to make a formed-in-place gasket, how do you determine what size of bead to use?

_____

_____

d. Which type of sealer—RTV or anaerobic—would be better suited to make a formed-in-place gasket for surfaces that flex?

_____

e. When replacing gaskets, why is it important that fasteners **not** be overtightened?

_____

_____

_____

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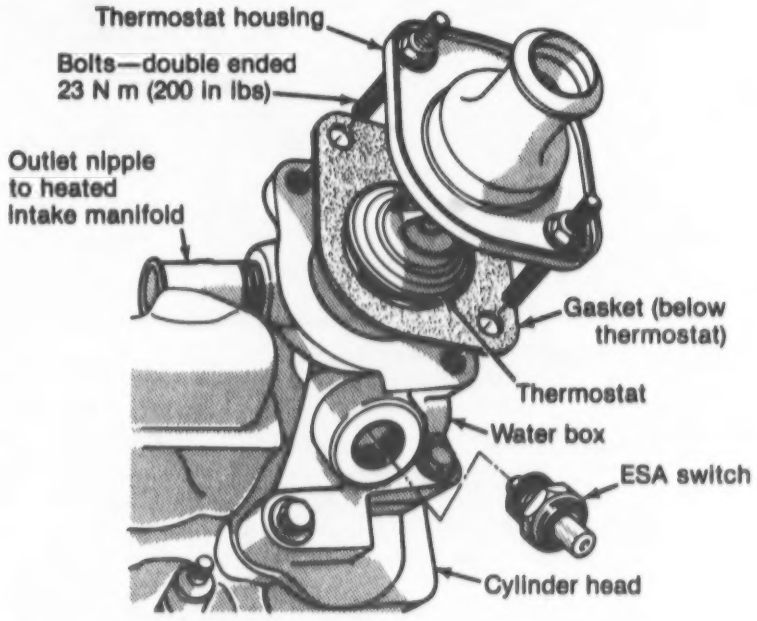
NOTE: For items *f* through *h*, refer to the illustration below.

Installation of thermostat on a Chrysler 1.6L engine

Place a new gasket (dipped in clean water) on water box surface, center thermostat in water box pocket on gasket. Place housing over gasket and thermostat, and bolt housing to water box. Tighten bolts to 23 N m (200 in lbs). Refill cooling system.



Used with permission of Chrysler Corporation.

f. Is it necessary to prepare the new gasket in any manner before it is installed? If so, how?

_____

_____

g. According to the information given, is a sealer used in conjunction with the gasket application?

_____

h. Beginning with the water box, what is the correct order of installation of the thermostat, thermostat housing, and gasket?

_____

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OBJECTIVE 8

List the types of automotive seals, and then write their descriptions. Write your answers in the blanks provided.

a. **Type** — _____

Description — _____

_____

_____

b. **Type** — _____

Description — _____

_____

_____

c. **Type** — _____

Description — _____

_____

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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WRITTEN TEST ANSWERS	REMOVE AND REPLACE SEALS AND GASKETS

OBJECTIVE 1

a. Material shaped to leakproof moving parts
b. Thin, compressible material placed between surfaces of nonmoving parts to prevent leakage

OBJECTIVE 2

a. 1
b. 3
c. 1
d. 2
e. 2
f. 1

OBJECTIVE 3

a. **Type** — Formed
Description — Gasket manufactured to fit the shape and hole arrangement of the parts it seals

b. **Type** — Formed-in-place
Description — Gasket user-made by applying special sealer to parts

c. **Type** — User-formed
Description — Gasket user-cut from gasket material to fit shape of parts it seals

OBJECTIVE 4

a. Use a chemical gasket remover; do **not** scrape, and do **not** use a wire brush
b. It should be replaced, and the fasteners should be retightened to the correct torque
c. Consult sealer manufacturer's specifications
d. RTV
e. Overtightening can damage metal parts and break the formed gasket or can squeeze the formed-in-place gasket sealer away from the mating surfaces
f. Yes; dip gasket in clean water
g. No
h. Water box, gasket, thermostat, thermostat housing

OBJECTIVE 8

a. **Type** — Ring seal
Description — Shaped rubber or neoprene ring

b. **Type** — Rope (packing) seal
Description — Braided fabric

c. **Type** — Lip-type seal
Description — Circular device with rubber- or neoprene-coated metal housing; may be spring reinforced

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OBJECTIVE SHEET

UNIT C-1 APPLY RELATED ELECTRICAL PRINCIPLES

INTRODUCTION

Today's vehicles contain many electrical components—such as electronic fuel controls, exterior and interior lamps and signals, instrument-panel lamps and gauges, horns, heated rear windows, electric door locks, and power seats and windows—as well as some electrical systems—such as the charging system, starting system, and the ignition system. As the number of automotive electrical components has increased, a working knowledge of basic electrical principles has become critical to the service specialist, who must now be able to apply these principles to troubleshoot problems and to make even the simplest electrical repairs.

UNIT OBJECTIVE

After completing this unit, the student should be able to state basic electrical principles and apply these principles in testing, diagnosing, and repairing electrical devices for vehicles. The student will demonstrate these competencies by completing assignment sheets, job sheets, and written test with a minimum accuracy of 85 percent.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit B-5, "Remove and Replace Seals and Gaskets."

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to

1. Recognize definitions of terms associated with automotive electrical systems by choosing the correct definition from a list of three choices.
2. Recall the electron theory of electricity by writing the theory.

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3. Distinguish between conductors and insulators by describing electron flow through each type of material and then stating the correct use of each.

4. Distinguish among basic electrical measurements by stating which measurement should be used when given a description of an electrical property to be measured.

5. Recall purposes of the components of a basic electrical circuit by writing the purpose of each component.

6. Distinguish among series, parallel, and series-parallel circuits by labeling illustrations of electrical circuits and then describing each circuit type.

7. Explain how a single-wire circuit functions by describing electron flow through the circuit.

8. Recognize descriptions of types of electrical-circuit problems by matching problems to their correct descriptions.

9. Recall types of circuit-protection devices and their functions by labeling illustrations of the devices and then describing how their designs affect current flow through a circuit.

10. Determine correct uses for electrical test equipment by stating the equipment that should be used for given situations.

11. Interpret electrical values from various digital multimeter settings. (Assignment Sheet 1)

12. Interpret automotive-circuit wiring diagrams. (Assignment Sheet 2)

13. Solder-splice electrical wiring. (Job Sheet 1)

14. Install terminals and connectors. (Job Sheet 2)

15. Measure current, voltage, and resistance with a multimeter. (Job Sheet 3)

16. Test and replace miniature light bulbs and test their sockets. (Job Sheet 4)

17. Explain principles of battery operation by describing electron flow during charging, discharging, and recharging.

18. Recall safety practices to follow when working with batteries by writing each rule when given a key word or phrase from the rule.

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19. Perform state-of-charge test on a conventional battery. (Job Sheet 5)

20. Perform state-of-charge check on a sealed battery. (Job Sheet 6)

21. Slow-charge a battery. (Job Sheet 7)

22. Perform battery load test. (Job Sheet 8)

23. Perform three-minute charge test. (Job Sheet 9)

24. Emergency jump-start a vehicle. (Job Sheet 10)

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SUGGESTED ACTIVITIES	APPLY RELATED ELECTRICAL PRINCIPLES

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstration of job-sheet procedures if unable to obtain suitable media.

- Obtain competency profiles for this unit. See ordering information in the "Suggested Resources" section.

- Prepare classroom and shop. Put up posters, charts, and signs. Have articles, specification guides, and remedial assignments available for student use.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Provide students with equipment and materials necessary to complete pretest. Administer pretest.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

- Modify materials in unit or create supplementary materials for individual students as required.

DELIVERY

Unit introduction

- Discuss introduction to the unit (see "Objective Sheet").

- Discuss the importance of the student's developing a working knowledge of basic electrical principles so that these principles can be applied when troubleshooting electrical problems in the complex electrical systems seen in today's vehicles. Discuss electrical systems, such as the charging system, starting system, and ignition system.

- Provide students with current shop manuals so that they may see wiring diagrams, troubleshooting charts, and specification charts used in electrical troubleshooting and repair.

- Take students on a tour of the shop, pointing out examples of electrical test equipment and briefly discuss their use.

- Use the DCA transparencies to illustrate your introduction to the unit.

Objective 1 Recognize definitions of terms associated with automotive electrical systems

- Go to the shop and on a vehicle point to examples that illustrate terms such as *primary wire*, *secondary wire*, and *wiring harness*. Have students examine and follow the wiring harnesses in the vehicle's engine or trunk.

- Display wiring diagrams used by the three major automotive manufacturers. Point out examples of the electrical-symbol style used by each manufacturer.

Objective 2 Recall the electron theory of electricity

- Discuss with students the note with this objective. Explain the need for each student to understand that being able to visualize the concepts of the electron theory is the basis for an understanding of the electrical principles to follow in the information sheet. Use the artwork in Figure 1 to help students visualize the concepts, or provide students with three-dimensional models of atoms to help with these concepts.

- Allow students to complete the Bergwall Apple II computer Program 1: "The Electron Theory," or show the Vocational Media Associates' filmstrip *Basic Electron Theory* or the NIMCO filmstrip *Electron Theory*. Have students complete the work sheet that accompanies the latter program.

Objective 3 Distinguish between conductors and insulators

- Use electron theory to explain the difference between a conductor and an insulator: a conductor is a material, such as copper, silver, gold, or iron, that allows electrons to flow through it easily; an insulator is a material, such as glass, nylon, plastic, rubber, or wood, that resists electron flow. To illustrate this concept, have students follow the directions for making a simple electroscope in the "One step more" box material with this objective.

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- Explain how conductors and insulators are utilized in electrical circuits throughout a vehicle: conductors are used to provide a pathway for electricity and insulators are used to keep electricity within the bounds of a circuit.

- Strip samples of automotive wire and show students the various types of conductors and insulators used in automotive circuits.

Objective 4 Distinguish among basic electrical measurements

- Electrical measurements are sometimes difficult for students to comprehend. Ask students to visualize volts, amperes, and ohms by comparing the flow of electrons along a wire to the flow of water through a pipe. Use the artwork and information in the box material with this objective as a basis for discussion in making this comparison.

- Show students the Vocational Media Associates' programs "Voltage," "Current," and "Resistance."

Objective 5 Recall purposes of the components of a basic electrical circuit

- Construct a basic electrical circuit, such as the one illustrated in Figure 2 with this objective. Discuss electron flow through the circuit and demonstrate the purpose of each circuit component: energy source, conductor, load, and switch.

- Show diagrams of typical automotive electrical circuits and point out the energy source, conductors, load, and switch in several automotive circuits.

Objective 6 Distinguish among series, parallel, and series-parallel circuits

- Explain to students that sometimes more complex circuits are required than the basic circuit presented in Objective 5. When two or more loads and possibly two or more switches are required in one circuit, three types of circuits are designed to meet these requirements: series, parallel, and series-parallel. Again, as you did for a basic electrical circuit, construct each of these types, using the artwork with this objective as a guide. Demonstrate what happens in each of these circuits when an open occurs in various places along the circuit.

- Show diagrams of typical automotive electrical circuits for each type presented: use a diagram of the dashlight circuit to explain the components and design of a series circuit, a taillight circuit to explain a parallel circuit, and the battery connections for starting large vehicles to explain a series-parallel circuit. Trace these diagrams and explain what happens in each of these circuits when an open occurs in various places along the circuit.

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- Show the Vocational Media Associates' filmstrip "Electrical Circuitry," have students complete the Bergwall Apple II Programs 4, 5, and 6, or show the NIMCO filmstrip *Electrical Circuits*.

Objective 7 Explain how a single-wire circuit functions

- Explain to students that the circuits they have studied in the previous objectives have all been similar in that they have contained at least two wires used as conductors leading from the energy source to the load and then back from the load to the energy source. Construct a single-wire circuit like the circuit in the diagram in the box material with this objective. Demonstrate how the metal bar in this diagram can be used as a conductor also, just like the frame of a vehicle is used to complete a circuit. Further explain that the pathway created by the vehicle frame is called a *ground*. Show students the ground symbol used on various automotive wiring diagrams.

Objective 8 Recognize descriptions of types of electrical-circuit problems

- Modify the basic series and single-wire circuits you constructed for previous objectives to demonstrate electrical-circuit problems: open circuits, short circuits, and high-resistance circuits. Demonstrate how current flow is affected in the intended circuit when each of these electrical problems occur.

- Discuss possible causes of each type of electrical problem and give clues to how these problems may be detected when troubleshooting automotive circuits. Use the box material "Causes of High Resistance" as an example when discussing causes of high-resistance circuits and as a model for discussing other electrical problems.

Objective 9 Recall types of circuit-protection devices and their functions

- Explain that the basic function of all circuit-protection devices is to protect other electrical circuit components from damage in case excessive amounts of current accidentally flow through the circuit. Have available samples of common automotive fuses, fusible links, and circuit breakers. Explain how each type of protection device is designed to open a circuit when excessive current flows through it. Also discuss the box material concerning fuse blocks or panels and have samples or diagrams of these available.

- Show the students wiring diagrams indicating the location of circuit-protection devices. Discuss the coding systems used by the various manufacturers to distinguish sizes of fuses and fusible links used in particular circuits.

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Objective 10 Determine correct uses for electrical test equipment

- Display examples of various types of jumper wires, test lights, and meters (analog and digital). Discuss with students the general uses presented in the information sheet, and then use the box material with the objective to discuss more specific testing applications.

- Have students complete Program 3 of the Bergwall Apple II series; or show Program 1 of the Bergwall VAT-40 series; the Vocational Media Associates' filmstrips "Introduction to Electrical Testing Devices," "Use of the Voltmeter," and "Use of the Ohmmeter;" or the NIMCO filmstrips *Voltmeters and Ammeters* and *Ohmmeter*.

Objective 11 Interpret electrical values from various digital multimeter settings

- Discuss with students the fact that digital meters are being used more and more today because they give more accurate readings and are more compatible with electronic circuits than the analog type.

- Also stress that separate voltmeters, ohmmeters, and ammeters may be used in the shop, but that a multimeter is a voltmeter, ammeter, and ohmmeter combined into one test instrument and that the skills learned in interpreting multimeter readings may be transferred to reading the separate instruments.

- Review with students the owner's manual for the meters used in your shop.

- Have students complete Assignment Sheet 1. Review in class when all students have completed.

Objective 12 Interpret automotive-circuit wiring diagrams

- Read and then discuss with the class the introduction to this assignment sheet. Stress that being able to interpret wiring diagrams is a necessary skill in performing automotive electrical work, as today's automotive electrical systems have become so complicated.

- Have students complete the Bergwall Apple II program "Circuits, Symbols, and Diagrams," or show Vocational Media Associates' filmstrip "How to Read Electrical Wiring Diagrams."

- Explain that wiring diagrams serve as the specialist's road map to these complex electrical systems and, although wiring diagrams may look complicated, interpreting the diagrams is an achievable skill that can be learned by separating interpretation into three areas: symbols, wiring codes, and guidelines for reading symbols and codes. Hand out Student Supplements 1 and 2, "Vehicle Manufacturers' Schematic Symbols" and "Automotive Wiring" to use as a basis for explaining symbols and wiring. Have students study the introduction to this assignment sheet to give them guidelines for reading symbols and codes. Then combine these separate skills by having them complete the exercises in the assignment sheet.

- Tell students they should not expect to be able to complete the exercises in the assignment sheet on the first try. These exercises will require practice and thorough understanding of the various styles used by the various manufacturers before the students will be able to easily interpret wiring diagrams on their own.

Objective 13 Solder-splice electrical wiring

- Show Program 1 of the Bergwall filmstrip series *Soldering for Electronic Repair*, or Program 5 of the Vocational Media Associates' filmstrip series *Basic Automotive Service*.

- Read with students the introduction to the job sheet, stressing that in order to make a good solder-spliced connection two requirements must be met: (1) a good physical connection must be made and (2) a good electrical connection must be made. A good physical connection is made through proper splicing procedures and a good electrical connection is achieved through proper stripping, soldering, and reinsulating procedures.

- Demonstrate using a wiring diagram to determine the wiring specifications of circuits to be repaired. Help students learn to apply the skills learned in Assignment Sheet 2. Then demonstrate proper stripping and cleaning, splicing, soldering, and reinsulating techniques for various voltage and wiring-size applications. During the demonstrations, discuss appropriate equipment and materials for each application, and emphasize that the materials used for low-voltage or -amperage circuits should never be used outside of that application. Demonstrate how certanium, the type of solder used for low-voltage or -amperage circuits, can melt if used in other circuit applications.

- Stress the need for using eye protection when applying solder, as hot solder can pop into the face and cause serious burns.

- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 14 Install terminals and connectors

- Show Programs 2 and 3 of the Bergwall filmstrip series *Soldering for Electronic Repair*.

- Read with the class the introduction to this job sheet. Have on display samples of the various types of terminals and connectors used in typical automotive circuits. Discuss the color codes used with solderless terminals and connectors and demonstrate using a wiring diagram for determining the location and specifications for terminals and connectors in circuits to be repaired. Help students learn to apply the skills they learned in Assignment Sheet 2.

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- Demonstrate the procedures presented in the job sheet and discuss appropriate equipment and materials to be used for each application.

- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 15 Measure current, voltage, and resistance with a multimeter

- Discuss with students the need to handle a multimeter with great care. It is a delicate instrument and can be damaged by being dropped or knocked about while in use. Demonstrate proper handling and storage techniques. Review meter reading and help students apply the skills they learned in Assignment Sheet 1.

- Demonstrate using a wiring diagram to determine the range of the circuit under test, the procedure for opening the circuit, and the best test location for the circuit. Help students learn to apply the skills they learned in Assignment Sheet 2.

- Carefully review the information in the manufacturer's instruction manual for the type of multimeter you make available in your shop. Discuss meter scales and settings and demonstrate hookup procedures for voltmeter, ammeter, and ohmmeter functions. Emphasize that a meter can be damaged or destroyed if hooked up incorrectly.

- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 16 Test and replace miniature light bulbs and test their sockets

- Show Program 1 of the Vocational Media Associates' filmstrip series *Basic Automotive Service*.

- Display types of light bulbs, sockets, and socket-and-bulb assemblies. Demonstrate reading service manual procedures and wiring diagrams in order to recognize the properties of the lighting circuit involved and to determine the type of test equipment to be used on the circuit, how to troubleshoot the various components of the circuit, how to get to a burned-out bulb, and how to determine the proper replacement bulb for the circuit if necessary. Help students to apply the skills they learned in Assignment Sheet 2.

- Demonstrate the procedures presented in the job sheet, stressing proper inspection and testing techniques for single- and dual-terminal sockets. Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 17 Explain principles of battery operation during charging, discharging, and recharging

- Display actual batteries that have had the cases cut away so that the internal components can be seen, or use diagrams showing cutaway views that are available in booklets from battery manufacturers, such as the training chart manuals available from Delco Remy. Using these visual aids, explain the location and chemical composition of the internal components of a typical battery and then discuss the chemical actions that take place during charging, discharging, and recharging.

Objective 18 Recall safety practices to follow when working with batteries

- When discussing this objective, emphasize that electrolyte is an acid and therefore can cause serious burns to skin and eyes. Review battery safety previously presented in Unit A-5, "Study Automotive Design," and display the battery safety teacher supplements from that unit in the classroom and shop.

- Show examples of the protective clothing students are required to wear to protect them from the serious burns that can result from electrolyte contact. Discuss your shop policy for the wearing of this protective equipment. Also discuss the fact that the vehicle's finish must be protected from contact with electrolyte and explain shop policy for the use of fender covers during battery service.

- As you did in Unit A-5, discuss again the need for keeping a baking-soda-and-water solution nearby when working with batteries, and show students how to properly mix this solution. Review first-aid procedures for accidental contact with electrolyte.

- Tell students that in the job sheets in this unit they will be performing various battery-service procedures that will require them to disconnect and connect battery cables and charging-equipment leads. Emphasize the extreme danger possible from explosion of battery gases if battery cables and charger leads are not disconnected and connected in an exact sequence. Demonstrate the sequence involved in properly connecting and disconnecting battery cables and charger leads and allow students to practice these procedures in a controlled environment.

- Show the NIMCO filmstrips *Battery Testing* and *Battery Servicing* or Program 4 of the Vocational Media Associates' filmstrip series *Basic Automotive Service.*

- Discuss the box material "It Could Never Happen to Me," which is presented in the information sheet with this objective. Point out other examples of accidents that have happened during battery service. Have students determine how these accidents could have been prevented.

Objectives 19 and 20

- Hand out copies of *Delco Remy's Training Chart Manual*, Sections B and F.

- Discuss with the class the information in Student Supplements 3 through 5, concerning battery types, troubleshooting, and replacement.

- Read with students the introduction to Job Sheet 5, "Perform State-of-Charge Test on a Conventional Battery." Relate the principles presented in the introduction to those presented in Objective 17. Emphasize how electrolyte weight (specific gravity) indicates battery state of charge and how a change in electrolyte temperature can affect specific gravity.

- Display and discuss various hydrometers; have samples of both temperature-compensating and non-temperature-compensating. Discuss reading the scales of these test instruments and demonstrate the calculations required when a non-temperature-compensating hydrometer is used. Also display and discuss the specific-gravity charts used to interpret temperature-compensated specific-gravity readings.

- Demonstrate procedures for testing the state of charge on a conventional battery and reemphasize specific safety rules for the procedure.

- Read with students the introduction to Job Sheet 6, "Perform State-of-Charge Check on a Sealed Battery." Display various types of sealed batteries and have students locate the built-in hydrometer on each.

- Use the artwork in the job-sheet introduction or the actual cage and sight glass from a built-in hydrometer to discuss how the hydrometer functions and how it is interpreted.

- Demonstrate procedures for checking the state of charge on a sealed battery and reemphasize specific safety rules for the procedure.

- Have students practice job-sheet procedures until they are ready to take the practical tests.

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Objective 21 Slow-charge a battery

- Read with students the introduction to this job sheet. Then display the charging equipment used in your shop and review the charger manufacturer's operating instructions. Demonstrate safe hookup procedures to be used when connecting and disconnecting charger leads to a battery and how to set charge rates and times.

- Also demonstrate and discuss the differences in the procedures used for slow-charging conventional and sealed batteries. Stress safety rules for determining whether a battery can be charged, for determining proper charge rate and time, and for disconnecting and connecting battery cables.

- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 22 Perform battery load test

- Read with students the introduction to this job sheet. Display the volt-amp tester used in your shop and review the tester manufacturer's operating instructions. Demonstrate safe hookup procedures to be used when connecting and disconnecting tester leads to a battery and how to adjust the load placed on a battery.

- Have students view the Vocational Media Associates' filmstrip "Volt-Amp Tester Hookup."

- Demonstrate how to read the tester to obtain a correct measure of battery voltage.

- Also demonstrate and discuss the differences in the procedures used for testing conventional and sealed batteries. Stress safety rules for determining whether a battery can be tested, for determining proper load to be placed on battery, and for disconnecting and connecting battery cables.

- Have students complete Program 3 of the Bergwall series *Troubleshooting with the VAT-40.*

- Have students practice job-sheet procedures until they are ready to take the practical test.

Objective 23 Perform three-minute charge test

- Review with students guidelines and safety rules for using the charging equipment in your shop. Stress proper hookup procedures and charging rates for this procedure. Also demonstrate proper voltmeter hookup and interpretation of voltmeter readings.

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- Demonstrate and discuss the differences in the procedures used for testing conventional and sealed batteries. Stress safety rules for determining whether a battery can be tested, for determining proper charge rate for battery, and for disconnecting and connecting battery cables.

- Have students practice job-sheet procedure until they are ready to take the practical test.

Objective 24 Emergency jump-start a vehicle

- This is a procedure that students may think they already know how to perform, but carefully review the information in the introduction of the job sheet in order to emphasize the serious damage that can be caused by performing this service incorrectly—damage to the vehicle's electrical system should the jumper cables be connected wrong or should the vehicle with the booster battery be started, and damage to the vehicle, to the specialist, and to any bystanders should the battery explode.

- Carefully demonstrate correct jumper-cable hookup procedures and discuss proper equipment and materials to be used while conducting the demonstration. Stress the importance of wearing protective clothing and following all battery-safety rules during the procedure.

- Have students practice job-sheet procedures until they are ready to take the practical test.

Unit summary activity

- Have students complete the Bergwall computer program *Fundamentals of Automotive Electricity* and print unit-quiz results.

EVALUATION

- Give written test.

- Give practical tests, and evaluate tests on forms provided.

- Reteach and retest as required.

- Complete appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- *Delco Remy Training Chart Manual: Section B, Energizers and Batteries*. Anderson, Indiana: Delco Remy, Division of General Motors, n.d.

- *Delco Remy Training Chart Manual: Section F, Freedom Batteries*. Anderson, Indiana: Delco Remy, Division of General Motors, n.d.

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- Derato, Frank C. *Automotive Electrical and Electronic Systems*. New York: Gregg Division, McGraw-Hill Book Company, 1986.
- *Electricity and Electronics, Section 1*. Centerline, Michigan: Chrylser Training Program Development Department, n.d.
- *Introduction to Automotive Mechanics: Unit 2, Lubrication, Cooling, and Safety Inspection Services*. Tallahassee, Florida: State of Florida, Department of Education, 1982.
- Mims, Forrest M., III. *Getting Started in Electronics*. Fort Worth, Texas: Radio Shack, A Division of Tandy Corporation, 1983.
- Mitchell Information Services, Inc. *Mitchell Automechanics*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.
- *Mopar Engine Service Guide*, publication no. 81-870-9001. Detroit, Michigan: Chrylser Corporation Service and Parts Division, Marketing and Product Development Department, 1978.
- Remling, John. *Automotive Electricity*. New York: John Wiley and Sons, 1987.
- Webster, Jay. *Auto Mechanics*. Encino, California: Glencoe Publishing Co., Inc., 1980.
- Westlund, Don. *Automotive Electrical Reference Manual*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983.

Media

NOTE: The following programs are available from Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, telephone 1-800-645-3565 (all states except New York) or 1-800-645-1737 (all states).

- *Basic Electricity and Electronics: Direct Current*. One diskette, one back-up, and a courseware guide are available with each of the six programs in this series designed to be used with an Apple II computer (48K). Topics included in each program are listed below. Programs may be purchased individually or as a set. The order number for the entire set is A801-V9. Order numbers for the individual programs are listed below.

  Program 1: "The Electron Theory" (A8011-V9) discusses atomic structure, current, voltage, and resistance.

  Program 2: "Circuits, Symbols, and Diagrams" (A8012-V9) covers symbols and diagrams, wiring circuits, ammeters, voltmeters, and wiring tools.

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Program 3: "Meter Reading and Ohm's Law" (A8013-V9) concerns reading meters, dry and wet cells, current and voltage, and Ohm's law.

Program 4: "Series Circuits" (A8014-V9) discusses series circuits, series loads, Kirchhoff's voltage law, polarity, open circuits, and fuses.

Program 5: "Parallel Circuits" (A8015-V9) covers current in parallel circuits, Kirchhoff's current law, ohmmeter and reciprocal formula, product/sum method, and finding shorts.

Program 6: "Resistors and Complex Circuits" (A8016-V9) concerns types of resistors, color codes, series-parallel circuits, and current in series-parallel circuits.

- *Fundamentals of Automotive Electricity*, order number AA51-V9. This computer program includes high-resolution graphics, animation, interactive questions, and unit quizzes with printable results. Program comes with a courseware guide and includes six copies of the program disk. Topics covered by the program are the electron theory (solar system, atom construction, insulators and conductors, electron theory), units of electricity (voltage, amperage, resistance, ohm's law), simple circuits (complete circuit, schematic symbols, open and short circuits, series circuits, voltage drops, parallel circuits, series-parallel circuits).

- *Troubleshooting with the VAT-40*, order number 441-V9. This five-program series can be purchased in a five-filmstrip/five-cassette (11 to 14 minutes each) version with a study guide or in a five-VHS-cassette (11 to 14 minutes each) version with a study guide. Produced in cooperation with the Sun Electric Company, topics included in each program are listed below. Programs 1 and 3 apply to this unit.

  Program 1: "Introduction and Meter Reading." Topics covered are how to identify starting and charging-system problems, connection procedure, meter use, and interpretation of meter readings.

  Program 2: "Performing System Tests." Topics include demonstrations of five go/no-go tests, battery performance, starting system, charging system, regulator, and diode stator.

  Program 3: "Testing Battery Performance." This program describes how to load test a battery, locate all battery problems, and evaluate the power-output capability of the charging system.

  Program 4: "Troubleshooting the Starting System." This program demonstrates how to perform circuit-resistance tests for insulated, ground, and switch circuits and how to locate excessive voltage drops across connections and cables.

Program 5: "Troubleshooting the Charging System." This program shows how to perform in-car tests of the alternator and generator, how to perform regulator-bypass tests, how to locate excessive voltage drops in charging circuits, and how to perform circuit-resistance tests.

- *Soldering for Electronic Repair.* This three-program series can be purchased in a three-filmstrip/three-cassette (20 to 23 minutes each) version with a study guide (order number 865-V9) or in a three-VHS-cassette (20 to 23 minutes each) version with a study guide (order number 865X-V9). Produced for basic electronics students, techniques included in the first two programs especially will transfer to techniques required in automotive mechanics. Topics in each program are listed below.

  Program 1: "Basic Techniques" explains various types of soldering and composition and types of solder; describes soldering tools; stresses safety in handling soldering equipment; and demonstrates how to solder a typical circuit-board connection.

  Program 2: "Soldering Terminals" describes common soldering terminals, shows steps for soldering each terminal type, and demonstrates how to solder a cable to a standard DB-25 connector, stressing safety and inspection of own work and clearly showing acceptable and unacceptable soldering techniques.

  Program 3: "Soldering Printed Circuit Boards" describes the printed circuit board and the use of the plating and solder mask; explains common electronic-component types, lead configuration, and integrated-circuit types; features component and board preparation and proper heat and solder application; stresses inspecting your own work; clearly shows acceptable and unacceptable circuit-board soldering; describes common printed-circuit-board soldering problems; and shows how to remove components and clean boards.

NOTE: The following programs are available from Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050.

- *Basic Electrical Theory and Test Equipment.* Order number 31275-169. This twelve-part filmstrip or sound-slide from Hoffman Information Systems productions stresses the concepts and applications related to automotive systems and standard testing devices. Titles of each of the twelve programs are listed below.

  "Basic Electron Theory"
  "Principles of Magnetism"
  "Voltage"
  "Current"
  "Resistance"
  "Electrical Circuitry"
  "How to Read Electrical Wiring Diagrams"

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"Introduction to Electrical Testing Devices"
"Use of the Voltmeter"
"Use of the Ohmmeter"
"Use of Tach-Dwell Panel"
"Volt-Amp Tester Hookup"

- *Basic Automotive Service.* Order number 30961-169. This five-part filmstrip or filmstrip-on-video with program guide focuses on basic service procedures required for maintaining a car in good working condition. Titles of each of the five parts are listed below along with a brief outline of each. Programs 1, 4, and 5 apply to this unit.

  Program 1: "Light Bulb Service" demonstrates how to remove and replace headlight and signal-light bulbs and discusses causes of burned-out bulbs.

  Program 2: "Oil Change and Lubrication" describes lubrication of chassis parts and shows how to change engine oil.

  Program 3: "Repairing a Puncture in a Radial Tire" describes how to determine the cause of a flat, explains steps for repairing a tire with a cold-cemented patch, and compares radial and bias-ply tires.

  Program 4: "Automobile Battery Service" illustrates how to check wet-cell batteries, shows how to clean the battery top, explains tests that determine electrical drain, demonstrates servicing battery cables and terminals and recharging batteries, and discusses load-testing readings.

  Program 5: "Electrical Wiring Procedures" focuses on replacing or adding electric wires and discusses examples of fusing, splicing, and soldering.

NOTE: The following transparency masters are available from DCA Educational Products Inc., Kellers Church Road, P.O. Box 338, Bedminister, Pennsylvania 18910.

- DCA produces six groups of transparencies in a 60-transparency *Auto Engine Systems* series with 42 overlays, an instructor's guide, and a library case. Titles of the six groups include "Engine Mechanical Systems," "Lubrication and Cooling Systems," "Fuel, Induction and Exhaust Systems," "Engine Electrical Systems," "Engine Tune-Up," and "Emission Control Systems." Order number for the series is AES000, but individual groups may be purchased separately. Group 4: "Engine Electrical Systems" is recommended for use with this unit and the titles and order numbers for the ten transparencies in this group are listed below.

  AES-30 "Electricity"
  AES-31 "Magnetism"
  AES-32 "Typical Electrical System"
  AES-33 "Battery Construction"
  AES-34 "Battery Visual Checks"

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AES-35 "Battery Tests"
AES-36 "Starter Construction"
AES-37 "Starting System Tests"
AES-38 "Alternator Construction"
AES-39 "Charging System Tests"

NOTE: The following filmstrips are available from NIMCO, National Innovative Media, Route 2, Box 3018, Calhoun, Kentucky 42327, telephone 1-800-962-6662 (all states except Kentucky).

- *Battery Testing*, order number MSJ-AT-M-12A. Set includes one cassette, one filmstrip (24 frames), and one work sheet.
- *Battery Servicing*, order number MSJ-AT-M-12B. Set includes one cassette, one filmstrip (28 frames), and one work sheet.
- *Electron Theory*, order number MSJ-AT-M-2A. Set includes one cassette, one filmstrip (29 frames), and one work sheet.
- *Ohm's Law*, order number MSJ-AT-M-2B. Set includes one cassette, one filmstrip (32 frames), and one work sheet.
- *Electrical Circuits*, order number MSJ-AT-M-2C. Set includes one cassette, one filmstrip (22 frames), and one work sheet.
- *Voltmeters and Ammeters*, order number MSJ-AT-M-6A. Set includes one cassette, one filmstrip (29 frames), and one work sheet.
- *Ohmmeter*, order number MSJ-AT-M-6B. Set includes one, cassette, one filmstrip (20 frames), and one work sheet.

Print media

NOTE: The following booklets, available from Delco Remy, Division of General Motors, Anderson, Indiana 46011, include good graphics and explanations of basic battery-operation principles.

- *Delco Remy Training Chart Manual: Section B, Energizers and Batteries.*
- *Delco Remy Training Chart Manual: Section F, Freedom Batteries.*

Other media

- Competency profiles and transparencies

  NOTE: Competency profiles and transparencies for this manual are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

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PRETEST ANSWERS

APPLY RELATED ELECTRICAL PRINCIPLES

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 2, 4
2	12, 34
3	35, 64
4	3, 13, 65
5	14, 36, 66, 67, 68
6	5, 15, 16, 37, 38, 69
7	17
8	18, 39, 40, 70, 71
9	19, 41, 72
10	20, 42, 73
11	23, 24, 45
12	59, 60, 61, 62, 63
13	6, 25, 26, 47
14	48, 49, 55, 56, 75
15	27, 28
16	29, 50, 51
17	21, 43, 46
18	22, 44, 57, 58, 74
19	30, 52
20	7
21	8, 11, 31
22	32
23	10, 53, 54
24	9, 33

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ANSWER KEY

1.	d	26.	b	51.	a
2.	a	27.	d	52.	b
3.	b	28.	a	53.	c
4.	b	29.	c	54.	a
5.	b	30.	b	55.	c
6.	d	31.	b	56.	b
7.	d	32.	b	57.	b
8.	b	33.	c	58.	d
9.	d	34.	d	59.	d
10.	c	35.	b	60.	c
11.	a	36.	a	61.	b
12.	a	37.	c	62.	a
13.	c	38.	a	63.	a
14.	d	39.	c	64.	b
15.	a	40.	c	65.	a
16.	b	41.	b	66.	c
17.	c	42.	a	67.	c
18.	b	43.	b	68.	b
19.	c	44.	c	69.	c
20.	c	45.	a	70.	d
21.	a	46.	c	71.	b
22.	a	47.	a	72.	c
23.	b	48.	a	73.	b
24.	d	49.	c	74.	d
25.	b	50.	d	75.	d

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PRETEST

APPLY RELATED ELECTRICAL PRINCIPLES

Name _____ Score _____

DIRECTIONS

Read the following questions and problems. Then circle the letter before the item that best answers the question or solves the problem.

1. Which of the following is the best definition of a *circuit*?

   a. Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits
   b. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires
   c. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
   d. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

2. Which of the following is the best definition of a *primary wire*?

   a. Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits
   b. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires
   c. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
   d. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

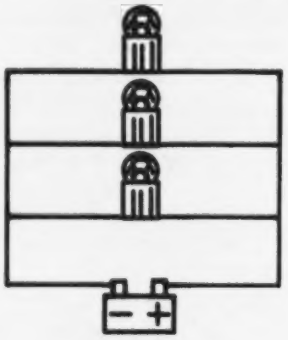
3. The basic electrical measurement used to measure the amount of opposition offered to the flow of electrons by the substance through which it is passing is called a/an _____.

   a. Ampere
   b. Ohm
   c. Volt
   d. Current

4. Which of the following is the best definition of a *wiring harness*?

   a. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source
   b. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
   c. Drawing that uses electrical symbols to show electrical circuits
   d. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires

5. The basic electrical circuit illustrated below is a _____ circuit.



   a. Series circuit
   b. Parallel circuit
   c. Series-parallel circuit

6. Technician A and B are discussing the appearance of a well-soldered joint. Technician A says that the cooled and hardened solder should appear shiny and contain tiny holes that are apparent to the eye. Technician B says that the solder should be dull and smooth with no apparent holes.

   Who is right?

   a. Technician A
   b. Technician B
   c. A and B
   d. Neither A nor B

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7. Which of the following is a correct standard for interpreting a state-of-charge check on a sealed battery?

   a. If a green dot shows in the hydrometer, battery is charged enough for further testing
   b. If a red dot shows in the hydrometer, battery must be slow-charged before further testing is performed
   c. If hydrometer appears clear or light yellow, battery must be replaced
   d. All of the above

8. When checking a sealed battery after a slow-charge, the battery is sufficiently charged when

   a. The red dot appears in the sight glass in the built-in hydrometer
   b. The green dot appears in the hydrometer's sight glass
   c. The hydrometer appears clear
   d. The hydrometer appears light yellow

9. Which of the following is **not** a correct guideline for connecting jumper cables to the batteries involved in an emergency jump start?

   a. Step 1, connect jumper-cable terminal clamp to positive terminal of booster battery
   b. Step 2, connect jumper-cable terminal clamp to positive terminal of discharged battery
   c. Step 3, connect jumper-cable terminal clamp to negative terminal of booster battery
   d. Step 4, connect jumper-cable terminal clamp to negative terminal of discharged battery

10. The three-minute charge test is a quick test used to determine whether a battery is simply discharged or really worn out; to conduct the test, you

    a. Connect a battery charger to the battery
    b. Connect a voltmeter to the battery
    c. Connect a voltmeter and a battery charger to the battery
    d. None of the above

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11. When preparing a battery for a slow-charge, you should

    a. Disconnect the grounded-terminal cable clamp first and the insulated-terminal cable clamp second
    b. Disconnect the insulated-terminal cable clamp first and the grounded-terminal cable clamp second
    c. Leave the grounded-terminal connected
    d. None of the above

12. Which of the following is a correct statement derived from electron theory?

    a. Everything is made up of atoms; atoms are made up of three elementary particles: protons, neutrons, and electrons
    b. Protons, which carry a negative charge, and neutrons, which carry no charge, make up the center of the atom, called the *nucleus*
    c. Electrons, which carry a positive charge, revolve around the nucleus in paths called *orbits*
    d. Positively charged electrons in the outer orbit are called *free electrons*

13. The basic electrical measurement used to measure the amount of electrical pressure causing electrons to flow is called a/an _____.

    a. Ampere
    b. Ohm
    c. Volt
    d. Current

14. Which of the components of a basic electrical circuit is a control device used to open and close a circuit?

    a. Energy source
    b. Conductor
    c. Load
    d. Switch

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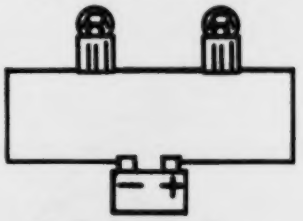
15. The basic electrical circuit illustrated below is a _____ circuit.



a. Series circuit
b. Parallel circuit
c. Series-parallel circuit

16. Which of the following best describes a *parallel* circuit?

a. Circuit has only one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any circuit component, current stops flowing through circuit and to all loads
b. Circuit has more than one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any one path, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads
c. Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel paths of the circuit; should an open occur in the path in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths of the parallel portion of the circuit, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

17. Which of the following is **not** a true statement describing how a single-wire circuit functions?

a. Circuit uses vehicle's frame as a part of the circuit
b. Electrons flow from negative battery terminal through frame, through load, back along insulated wire, through switch, and then to positive battery terminal
c. Electrons flow from positive battery terminal through switch, along insulated wire, through load, and back along frame to negative battery terminal
d. Electrons flow from positive battery terminal through frame, through load, back along insulated wire, through switch, and then to negative battery terminal

18. Which of the following best describes a *wire-to-wire short circuit*?

a. Condition caused by a break in a circuit, causing current to stop flowing through the circuit
b. Condition caused when a conductor in an intended circuit touches a conductor in another circuit, causing current to flow in the other circuit and power a different load
c. Condition caused when a conductor in an intended circuit touches a ground connection, creating an accidental ground
d. Condition usually caused by a loose or badly corroded connection, causing a reduction of current flowing in a circuit

19. "Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that soft-metal conductor melts and permanently opens circuit when excessive current flows through it" best describes which of the following circuit-protection devices?

a. Circuit breaker
b. Fusible link
c. Fuse
d. Fuse panel

20. Which of the following is the correct use of the electrical test equipment called a *test light*?

a. Used for measuring voltage, current, and resistance
b. Used for bypassing a portion of a circuit
c. Used for checking to see that voltage is present in a circuit

21. The following sequence describes battery operation during the _____ phase.

(1) Two plates made from dissimilar conductors (lead peroxide and spongy lead) are placed in a sulfuric-acid-and-water solution called *electrolyte*. (2) Acid attacks lead-peroxide plate (positive plate), releasing electrons that are attached to spongy-lead plate (negative plate). (3) Negative plate becomes full of electrons.

a. Charging
b. Discharging
c. Recharging

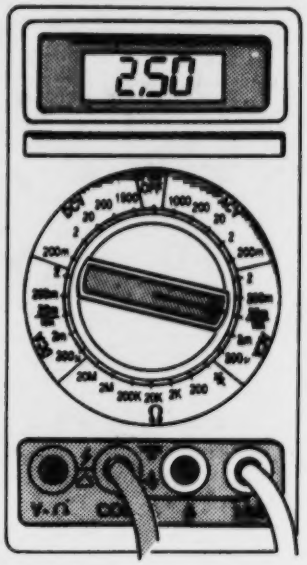
1274

22. Technician A says that when using a battery charger you should make connections before plugging the charger into the power supply. Technician B says that the connections should be made after plugging the charger into the power supply.

Who is right?

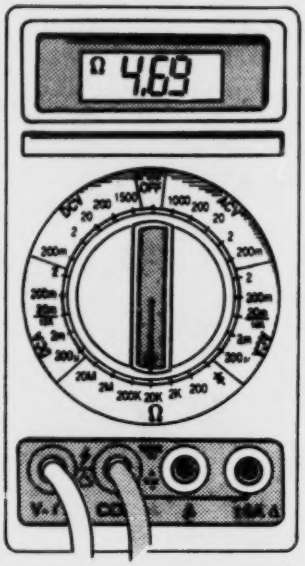
a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

23. Which of the following is the correct reading on the multimeter illustrated below?



a. 2.50 volts
b. 2.50 amps
c. 250 amps
d. 2.50 ohms

24. Which of the following is the correct reading on the multimeter illustrated below?



a. 4.69 volts
b. 4.69 amps
c. 4.69 ohms
d. 46,900 ohms

25. Which of the following is a guideline that should be followed when you are solder-splicing electrical wiring?

a. The recommended method of stripping small-gauge wire is to scrape the insulation from the wire with a razor blade
b. When twisting stranded wiring, you should twist the wiring in the direction of the strand twist
c. When reinsulating a solder-spliced connection with heat-shrink insulation, use the heat from a match flame, but do not allow the flame to actually touch the insulation
d. Use acid-core solder for soldering electrical wiring

1276

26. When preparing a soldering-iron or -gun tip for use, which of the following guidelines should be followed?

    a. When iron or gun is cool, inspect all tips for proper wedge shape; file gold and iron tips as necessary
    b. When iron or gun is hot, use tip of clean screwdriver to place a drop of tinning oil or flux onto each tip surface
    c. Holding hot iron or gun over wet sponge, apply acid-core solder to each tip surface; wipe excess solder from tip onto wet sponge
    d. After applying solder to tip surface, immediately begin soldering procedure

27. Which of the following is a true statement concerning attaching test probes at circuit test locations when using a multimeter to measure current, voltage, or resistance?

    a. When measuring current (amperage), attach test probes in series at circuit test location
    b. When measuring voltage, attach test probes in parallel at circuit test location
    c. When measuring resistance (ohms), attach test probes in parallel at circuit test location
    d. All of the above

28. Technician A and B are discussing correct procedures for measuring current, voltage, and resistance with a multimeter. Technician A says that, when measuring resistance, you must zero the meter each time you move the range-selector switch to a new resistance position. Technician B says that the meter need only be adjusted to zero before the first ohms reading is taken.

    Who is right?

    a. Technician A
    b. Technician B
    c. A and B
    d. Neither A nor B

1277

29. Which of the following is **not** a correct statement concerning testing sockets of miniature light bulbs?

a. Various types of miniature bulbs are used throughout a vehicle: single-filament, single-contact bulbs with single-terminal sockets; double-filament, double-contact bulbs with dual-terminal sockets; friction-fitted wedge-shaped bulbs with rubber or plastic sockets
b. When testing a single-terminal light socket, clip ground clip of test light to socket housing and touch sharp point of test-light probe to light-socket terminal, but do **not** allow the probe to contact the socket housing
c. When testing a single-terminal light socket, clip ground clip of test light to socket housing, check vehicle diagram to determine where on socket housing to place sharp point of test-light probe, and carefully place probe on that point
d. When testing a dual-terminal light socket, clip ground clip of test light to socket housing, check wiring diagram to determine which terminal should be tested, and touch sharp point of test-light probe to that terminal, but do **not** allow the probe to contact the socket housing

30. Technician A and B are discussing the procedure for performing a state-of-charge test on a conventional battery. Technician A says that 70 degrees F is the accepted electrolyte-temperature standard for specific-gravity readings, and when using a non-temperature-compensating hydrometer, you must add four gravity points for every 10 degrees of electrolyte temperature above 70 degrees. Technician B agrees that you must add four gravity points for every 10 degrees of electrolyte temperature above the accepted temperature standard, but she believes the electrolyte-temperature standard is 80 degrees F.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

1278

31. Technician A and B are discussing correct procedures for slow-charging a conventional battery. Technician A says a fully charged battery will spew liquid electrolyte from the filler holes, specific gravity will test between 1.260 and 1.280, and specific-gravity readings will drop after a three-hour period. Technician B says a fully charged battery will gas freely and no change will occur in specific gravity readings when tested over a three-hour period.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

32. Technician A and B are discussing correct procedures for conducting a battery load test. Technician A says that you connect a volt-amp tester to the battery terminals, adjust the load-control knob to a predetermined load, maintain the load for 15 seconds, and then read the voltmeter to obtain a measure of the battery's voltage. Technician B says that you connect a volt-amp tester to the battery terminals, adjust the load-control knob to a predetermined load, maintain the load for 15 seconds, turn the knob to OFF, wait 15 seconds, turn the load-control knob back to the predetermined load for 15 seconds, and then read the voltmeter to obtain a measure of the battery's voltage.

Who is right?

a. Technician A
b. Technician B
c. Both A or B
d. Neither A nor B

33. Technician A and B are discussing correct procedures for jump-starting a vehicle. Technician A says that the booster battery may be a separate battery brought to the vehicle with the discharged battery, or it may be a battery in another vehicle. Technician B says that if the booster battery is in a vehicle, you should never start the engine of that vehicle during the procedure.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

1279

34. Which of the following is **not** a correct statement derived from electron theory?

a. Everything is made up of atoms; atoms are made up of three elementary particles: protons, neutrons, and electrons
b. Protons, which carry a positive charge, and neutrons, which carry no charge, make up the center of an atom, called the *nucleus*
c. Electrons, which carry a negative charge, revolve around the nucleus in paths called *orbits*
d. The flow of protons from the nucleus to the outer orbits of the atom is called *electricity*

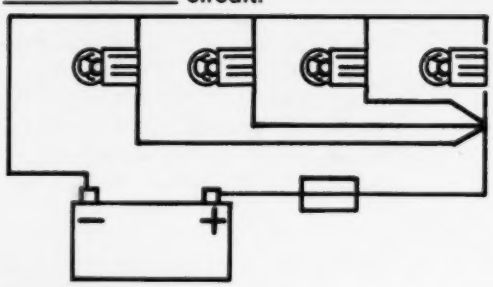
35. Which of the following is the best definition/use of a *conductor*?

a. Material that resists electron flow; used to keep electricity within bounds
b. Material that allows electrons to flow through it easily; used to provide a pathway for electricity
c. Neither a nor b

36. Which of the following is the best definition of the purpose of the *energy source* in a basic electrical circuit?

a. Produces the energy that causes electrons to flow
b. Provides a pathway through which electrons flow
c. Converts electrical energy into some other form of energy—heat, light, or mechanical energy
d. Opens and closes circuit

37. The basic electrical circuit illustrated below is a _____ circuit.



a. Series circuit
b. Parallel circuit
c. Series-parallel circuit

1200

38. Which of the following best describes a *series* circuit?

a. Circuit has only one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any circuit component, current stops flowing through circuit and to all loads
b. Circuit has more than one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any one path, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads
c. Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel path of the circuit; should an open occur in the path in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths of the parallel portion of the circuit, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

39. "Condition caused by a break in a circuit, causing current to stop flowing through the circuit" best describes which type of electrical-circuit problem?

a. High-resistance circuit
b. Short circuit
c. Open circuit
d. Wire-to-wire short

40. Which of the following best describes a *short-to-ground*?

a. Condition caused by a break in a circuit, causing current to stop flowing through the circuit
b. Condition caused when a conductor in an intended circuit touches a conductor in another circuit, causing current to flow in the other circuit and power a different load
c. Condition caused when a conductor in an intended circuit touches a ground connection, creating an accidental ground
d. Condition usually caused by a loose or badly corroded connection, causing a reduction of current flowing in a circuit

41. Which of the following best describes a *fusible link*?

a. Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that soft-metal conductor melts and permanently opens circuit when excessive current flows through it
b. Specially insulated wire connected in circuit; designed so that insulation puffs and smokes and then wire melts and permanently opens circuit when excessive current flows through it
c. Device containing a bimetal strip and a set of points; designed so that when excessive current flows through it, bimetal strip bends away from contact points and temporarily opens circuit until strip cools and again touches contact points
d. Fuses and circuit breakers for major circuits grouped in a panel usually located under the dash near the headlight switch, in the glove compartment, or in the engine compartment

42. Which of the following is the correct use of the electrical test equipment called a *multimeter*?

a. Used for measuring voltage, current, and resistance
b. Used for bypassing a portion of a circuit
c. Used for checking to see that voltage is present in a circuit

43. The following sequence describes battery operation during the _____ phase.

(1) Battery circuit is closed. (2) Potential causes electrons to flow through circuit to load, pulling electrons away from negative plate. (3) As electrons are pulled away from negative plate, plates become similar in composition and acid in electrolyte decreases. (4) As positive and negative plates become more similar, battery voltage decreases.

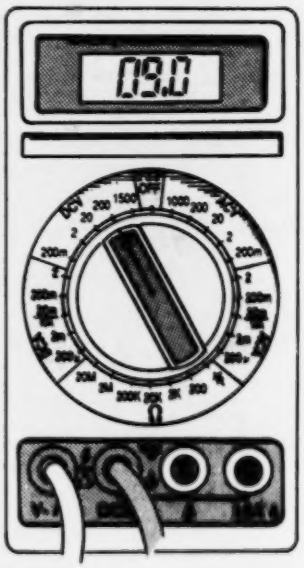
a. Charging
b. Discharging
c. Recharging

1282

44. Which of the following is a correct statement concerning battery safety practices?

a. Use fender covers to protect vehicle finish and metal surfaces from accidental electrolyte spillage
b. Always keep a mixture of baking soda and water nearby to wash vehicle's metal surfaces if electrolyte is spilled or splashed on the vehicle
c. Both a and b
d. Neither a nor b

45. Which of the following is the correct reading on the multimeter illustrated below?



a. 9 volts positive
b. .09 ohms
c. 9 amps
d. .09 volts positive

1283

46. The following sequence describes battery operation during the _____ phase.

(1) Direct current is forced through battery, supplying electrons to positive plate, making positive and negative plates become dissimilar again and building up acid in electrolyte. (2) Again the acid in the electrolyte attacks positive plate and electrons go to negative plate.

a. Charging
b. Discharging
c. Recharging

47. Technician A and B are discussing soldering techniques used for repairing electrical wiring. Technician A says that the tip of the soldering iron or gun should be held so that a large area of the tip contacts the wiring to be soldered and that the solder should be held on the wiring until the wiring itself gets hot enough to melt the solder. Technician B says that the tip of the soldering iron or gun should be held so that a large area of the tip contacts the wiring and that the solder should also be held on the tip of the iron or gun.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

48. A _____ is a small conductive metal device attached to the end of a wire so that the wire may be easily connected and disconnected to other wires or electrical-circuit components.

a. Terminal
b. Connector
c. Splice
d. Joint

1284

49. Solderless terminals and connectors are color-coded to ensure that you select the proper terminal or connector for the conductor to which it will be attached. Which of the following is a correct statement about the color code?

    a. Solderless terminals and connectors with blue ends are used with 18-gauge and smaller conductors
    b. Solderless terminals and connectors with red ends are used with 14- and 16-gauge conductors
    c. Solderless terminals with yellow ends are used with 10- and 12-gauge conductors
    d. All of the above

50. Which of the following guidelines should **not** be applied when you are testing and replacing miniature light bulbs?

    a. The exact procedure for exposing a particular bulb for a particular vehicle must be found in the vehicle-manufacturer's service manual
    b. Lenses covering exterior lights and some lenses covering interior lights are held in place by screws located on the edge of the lens or frame; when removing the lens screws, you must hold the lens firmly and remove it very carefully so that you do not break the lens or tear the gasket that is often located between the lens and its mounting
    c. Lenses for many interior lights are usually of the type that snap into place and are removed by squeezing the lens or by prying it loose from its mounting; when removing this type of lens, you must hold the lens firmly and remove the lens carefully so that you do not break the lens
    d. Pull-out socket-and-bulb assemblies usually have locating-keys or -tabs on the socket that align with slots on the vehicle's body; to remove the assembly from the vehicle, you must push in the socket assembly and turn it clockwise so that the keys or tabs are aligned properly with the slots for removal

1285

51. Technician A and B are discussing proper procedures for testing sockets of miniature light bulbs. Technician A and B agree that before testing a socket you must check the vehicle's wiring diagram to determine whether or not there are electronic components in the circuit. However, they disagree on the type of test light that should be used during the test. Technician A says that if there are electronic components in the circuit you must use an LED-type test light. Technician B says that a bulb-type test light should be used.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

52. Which of the following is the correct standard for interpreting state-of-charge-test hydrometer readings for a conventional battery?

a. Readings for all cells must be within the range given for normally charged cells of battery type, and cell readings must all be within 0.025 points of each other
b. Readings for all cells must be within the range given for normally charged cells of battery type, and cell readings must all be within 0.050 points of each other
c. Neither a nor b

53. The reading taken when performing a three-minute charge test is interpreted using which of the following guidelines?

a. If the reading is less than 15.5 volts, the battery is probably just discharged and will accept a charge
b. If the reading is above 15.5 volts, the battery is probably worn out and will not accept a charge
c. Both a and b
d. Neither a nor b

1266

54. Technician A and B are discussing a three-minute charge test. Technician A says that the battery must be disconnected from the vehicle's electrical system to prevent surges that could cause severe damage to the vehicle's electrical system. Technician B says that because of the low charging rates used during the three-minute charge, the battery may remain connected to the vehicle's electrical system.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

55. Technician A and B are discussing proper techniques for soldering a terminal or a connector in place. Technician A says that only enough rosin-core solder should be applied to attach the terminal or connector securely and that the connection will break if too much solder is used. Technician B says that if the soldered connection seems loose when tested, the wire should be reheated to melt the solder more thoroughly.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

56. A _____ is a nonconductive plastic device that provides a way of disconnecting components or a portion of a circuit from the main wiring harness.

a. Terminal
b. Connector
c. Splice
d. Joint

1287

57. A technician is working with a battery inside a vehicle; which of the following articles of protective clothing should she be wearing?

a. Safety glasses and rubber gloves
b. Safety glasses, rubber gloves, and rubber apron
c. Safety glasses and rubber apron
d. Rubber gloves and rubber apron

58. Technician A and B are discussing safe procedures for performing battery service. Technician A says that it is safe to jump-start, charge, and test a sealed battery when the hydrometer appears clear or light yellow. Technician B disagrees and says you should not jump-start, charge, or test a sealed battery with a clear or light yellow hydrometer.

Who is right?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

NOTE: Refer to the wiring diagram on the following page to answer questions 59 through 63.

59. What size fuse is used for the air-conditioning and heater?

a. 10-amp
b. 12-amp
c. 20-amp
d. 30-amp

60. The neutral start switch is located in what circuit?

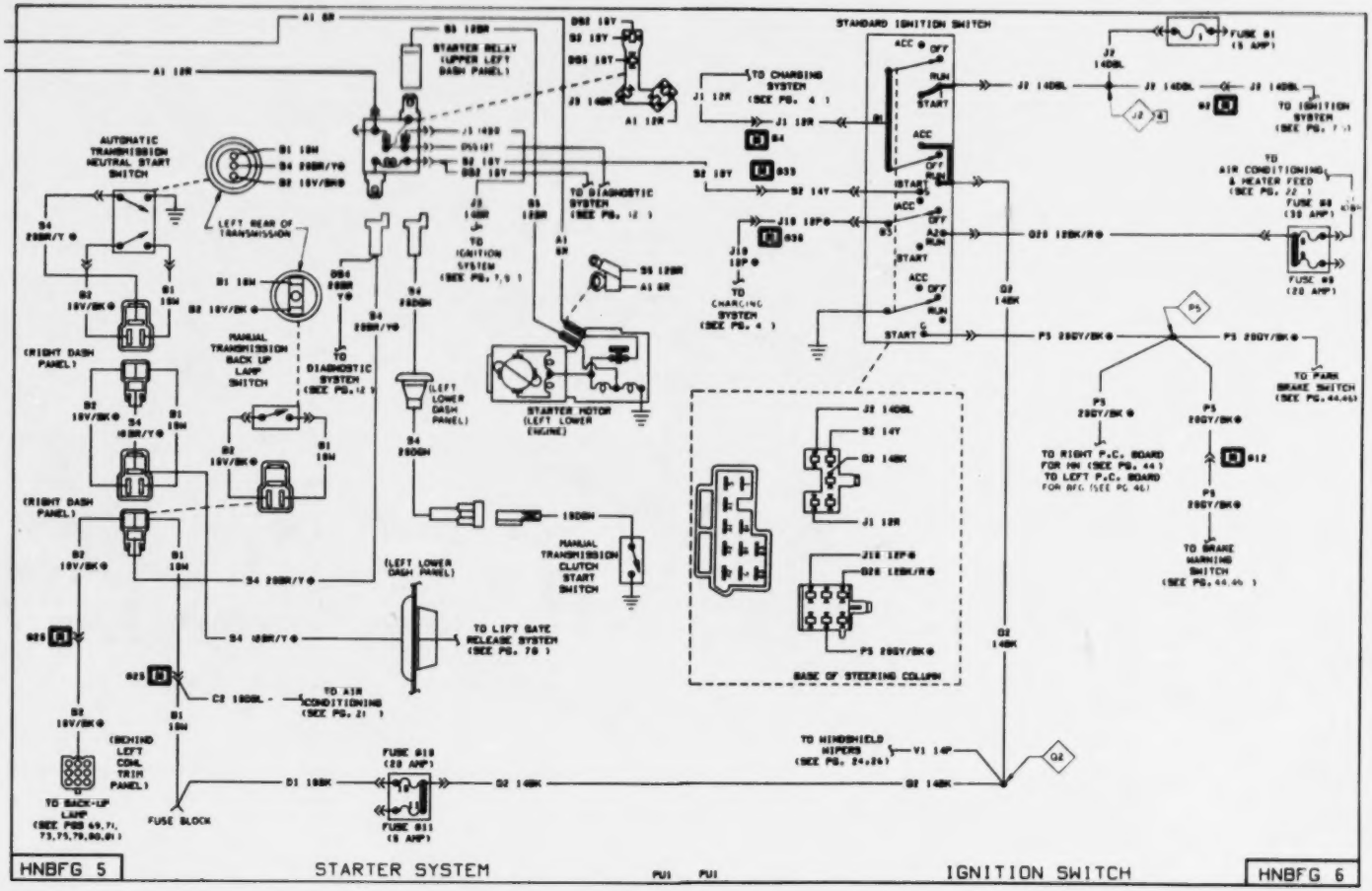
a. A1
b. S1
c. S4
d. S5

61. What color wire is used for the back-up lamp switch?

a. Yellow
b. Purple with a black stripe
c. Dark green
d. Blue

1288

Used with permission of Chrysler Motor Corporation.



1289

1290

62. How many circuits are in the neutral-start switch?

a. 2
b. 3
c. 4
d. 5

63. What size wire is used for the back-up lamp switch?

a. 18-gauge
b. 12-gauge
c. 10-gauge
d. 14-gauge

64. A material that resists electron flow and is used to keep electricity within bounds is called a/an _____.

a. Conductor
b. Insulator
c. Primary wire
d. Secondary wire

65. The basic electrical measurement used to measure the number of electrons flowing past a given point per second is called a/an _____.

a. Ampere
b. Ohm
c. Volt
d. Current

66. Which of the components of a basic electrical circuit converts electrical energy into some other form of energy—heat, light, or mechanical energy?

a. Energy source
b. Conductor
c. Load
d. Switch

1291

67. Which of the following is the best definition of the purpose of the *load* in a basic electrical circuit?

a. Provides the energy that causes electrons to flow
b. Provides a pathway through which electrons flow
c. Converts electrical energy into some other form of energy—heat, light, or mechanical energy
d. Opens and closes circuit

68. Which of the components of a basic electrical circuit provides the pathway through which electrons flow from the energy source through the load and back to the energy source?

a. Energy source
b. Conductor
c. Load
d. Switch

69. Which of the following best describes a series-parallel circuit?

a. Circuit has only one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any circuit component, current stops flowing through circuit and to all loads
b. Circuit has more than one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any one path, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads
c. Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel paths of the circuit; should an open occur in the path in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths of the parallel portion of the circuit, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

70. "Condition usually caused by loose or badly corroded connection, causing a reduction of current flowing in a circuit" best describes which of the following electrical-circuit problems?

a. Open circuit
b. Short circuit
c. Wire-to-wire short circuit
d. High-resistance circuit

71. "Condition caused when current bypasses a part of an intended circuit, causing current to flow in an accidental circuit" best describes which of the following electrical-circuit problems?

a. Open circuit
b. Short circuit
c. Wire-to-wire short circuit
d. High-resistance circuit

72. Which of the following best describes a *circuit breaker*?

a. Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that soft-metal conductor melts and permanently opens circuit when excessive current flows through it
b. Specially insulated wire connected in circuit; designed so that insulation puffs and smokes and then wire melts and permanently opens circuit when excessive current flows through it
c. Device containing a bimetal strip and a set of points; designed so that when excessive current flows through it, bimetal strip bends away from contact points and temporarily opens circuit until strip cools and again touches contact points
d. Fuses and circuit breakers for major circuits grouped in a panel usually located under the dash near the headlight switch, in the glove compartment, or in the engine compartment

73. Which of the following is the correct use of the electrical test equipment called *jumper wires*?

a. Used for measuring voltage, current, and resistance
b. Used for bypassing a portion of a circuit
c. Used for checking to see that voltage is present in a circuit

74. Which of the following rules should be observed when working with batteries?

a. Do not smoke near a battery on charge or recently charged
b. Do not break live circuits at battery
c. Never lay any conductor across battery terminals
d. All of the above

75. Two requirements must be met when terminals and connectors are installed: (1) a good physical connection and (2) a good electrical connection must be made. To meet these requirements, which of the following guidelines apply?

a. Terminals and connectors to be used in locations exposed to moisture must be soldered in place
b. Terminals and connectors to be used in circuits carrying large amounts of current must be soldered in place
c. For most applications, solderless terminals and connections can be crimped to wires with the crimping area of a wire-stripping-and-crimping tool
d. All of the above

INFORMATION SHEET

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 1

Recognize definitions of terms associated with automotive electrical systems

Circuit — Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

Primary wire — Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits

NOTE: Primary wire is measured in gauge numbers. The higher the gauge number, the smaller the wire.

Secondary wire — High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires

Wiring harness — System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle

Wiring diagram (schematic) — Drawing that uses electrical symbols to show electrical circuits

1295

OBJECTIVE 2

Recall the electron theory of electricity

NOTE: In order to service the electrical equipment in a vehicle, you must have a basic understanding of the nature of electricity. Scientists use electron theory to describe how they believe electricity is produced. The following are simplified statements derived from electron theory.

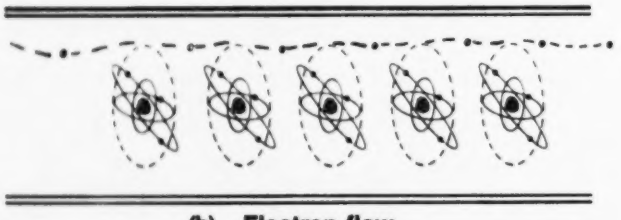
Electron theory

- Everything is made up of atoms
- Atoms are made up of three elementary particles: protons, neutrons, and electrons (Figure 1[a])
- Protons, which carry a positive charge (+), and neutrons, which carry no charge, make up the center of the atom, called the *nucleus* (Figure 1[a])
- Electrons, which carry a negative charge (–), revolve around the nucleus in paths called *orbits*; electrons in the outer orbit are called *free electrons* (Figure 1[a])
- In some elements, when free electrons are energized, they move (flow) from one atom to another; this flow of electrons is called *electricity* (Figure 1[b])

EXAMPLE:

FIGURE 1

(a) Copper atom



(b) Electron flow

1296

OBJECTIVE 3 | **Distinguish between conductors and insulators**

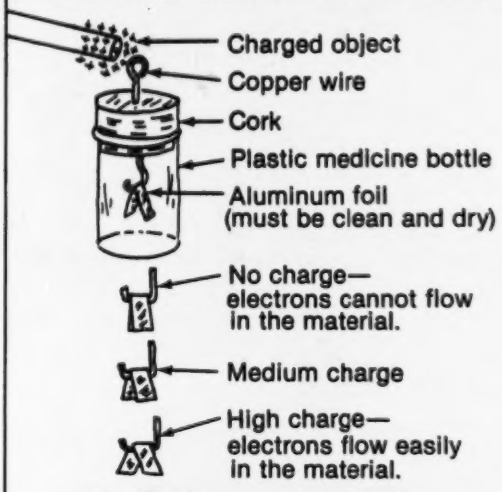
Conductor — Material that allows electrons (electricity) to flow through it easily; used to provide a pathway for electricity

Insulator — Material that resists electron flow (electricity); used to keep electricity within bounds

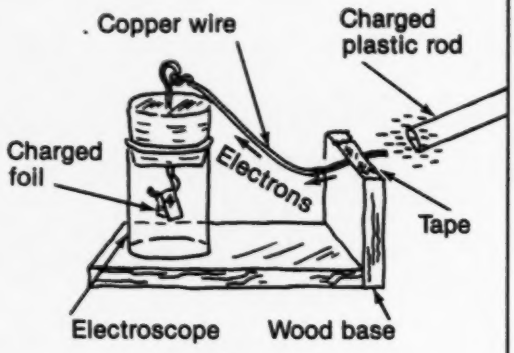
One step more . . .

You can make an electroscope and use it to prove that electrons travel through some materials more easily than others. Construct your electroscope using the materials in illustration (a) below. Then, if you touch an object to the copper-wire hook, the foil strip in the medicine bottle will react in one of the ways also shown in illustration (a).

Now, put your electroscope on a wood base and attach a copper wire to the copper hook and to the base. Charge a plastic rod by rubbing the rod on a piece of wool or fur, and then touch the rod to the copper wire. The aluminum foil will respond. See illustration (b) below. This demonstration shows that electrons can travel through copper, and therefore, copper is a *conductor*. Other common conductors include silver, gold, and iron.



(a) Electroscope construction



(b) Electroscope responding to a conductor

Replace the copper wire with a nylon cord and touch the charged rod to the cord. The aluminum foil in the electroscope will not respond. This demonstration shows that electrons cannot travel through nylon, and therefore, nylon is an *insulator*. Other common insulators include glass, plastic, rubber, and wood.

Illustrations (a) and (b) from *Getting Started in Electronics*, by Forrest M. Mims, III (Radio Shack, 1983). Used with permission.

OBJECTIVE 4

Distinguish among basic electrical measurements

Volt (V or E) — Measures voltage: the amount of electrical pressure causing electrons to flow

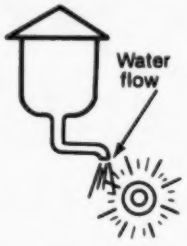
Ampere (Amp, A, or I) — Measures electrical current: the number of electrons flowing past a given point per second

Ohm (Ω or R) — Measures resistance: the amount of opposition offered to the flow of electrons by the substance through which it is passing

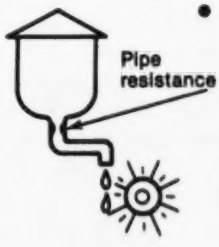
Visualizing Volts, Amperes, and Ohms

A good way to visualize electrical measurements (volts, amperes, and ohms) is to compare the flow of electrons through a conductor to the flow of water through a pipe.

- In order for water to flow through a pipe, it must be pushed along by water pressure. For electrons to flow through a conductor, pressure is also necessary. The pressure that pushes electrons through a conductor is called *voltage*, which is measured in volts, abbreviated *E* or *V*.



- The amount of water flowing past a certain point on a pipe (usually from the end of the pipe) can be measured in gallons per minute. Likewise, the number of electrons flowing past a certain point per second can be measured in *amperes*, abbreviated *amps*, *A*, or *I*.



- Just as the diameter of a pipe creates resistance to the water flowing through it—a small pipe producing more resistance than a larger one—a smaller conductor of a given material produces more resistance to the electrons flowing through it than does a larger one. And also, the longer the conductor, the greater the resistance it produces. Resistance is measured in *ohms*, abbreviated *Ω* or *R*.

Illustrations used with permission of Chrysler Motor Corporation.

OBJECTIVE 5

Recall purposes of the components of a basic electrical circuit

NOTE: A circuit is a combination of components connected to form a pathway through which electrons can flow. This pathway is used to power different electrical devices (electric motor, lights, etc.) that convert electron flow (electrical energy) into other forms of energy, such as heat, light, or mechanical energy. The basic components of this pathway include an energy source, conductors, a load (electrical device), and a switch. See Figure 2 below.

Energy source — Produces the energy that causes electrons to flow

NOTE: The most common energy sources used in electrical circuits are batteries and generators.

Conductors — Provide pathway through which electrons flow from energy source through load and back to energy source

NOTE: Copper wire is the most commonly used conductor. Often this copper wire is covered with one or more layers of insulating material to keep the electrons from contacting another conductor and moving outside the bounds of the circuit's pathway.

Load — Converts electrical energy into some other form of energy—heat, light, or mechanical energy

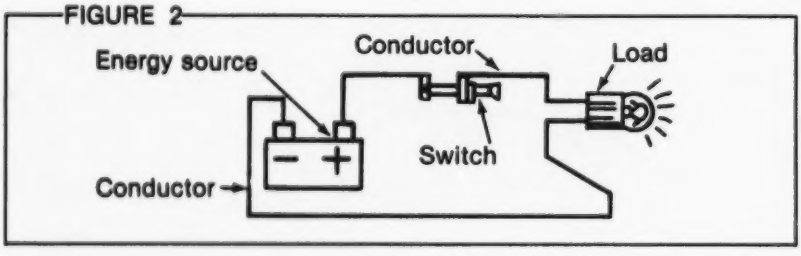
NOTE: Typical automotive loads include lights, horns, and electric motors.

Switch — Opens and closes circuit

NOTE: A switch is a control device used to open and close a circuit. When the switch is on (the circuit is closed), it acts as a conductor, completing the pathway that allows the electrons to flow away from the energy source through the load and back to the energy source. When the switch is off (the circuit is open), it breaks the pathway, stopping the flow of electrons from the energy source through to the load. Electrons will not flow through a circuit if the circuit is broken anywhere along the pathway.

EXAMPLE:

FIGURE 2



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OBJECTIVE 6

Distinguish among series, parallel, and series-parallel circuits

NOTE: A basic circuit contains only one load and one switch. However, sometimes more complex circuits are required when two or more loads (and possibly two or more switches) must be connected in one circuit. Three types of circuits are designed to meet such requirements: series, parallel, and series-parallel.

Series circuit (Figure 3[a])

EXAMPLE: Dashlight circuit

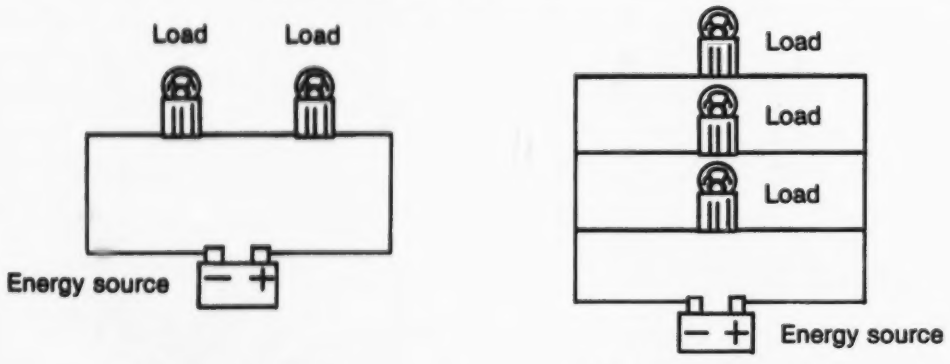
- Circuit has only one path for electricity to flow from energy source through loads (and switches) and then back to energy source
- Should an open occur in any circuit component, current stops flowing through circuit and to all loads

Parallel circuit (Figure 3[b])

EXAMPLE: Tail-light circuit

- Circuit has more than one path for electricity to flow from energy source through loads (and switches) and then back to energy source
- Should an open occur in any one path, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

FIGURE 3



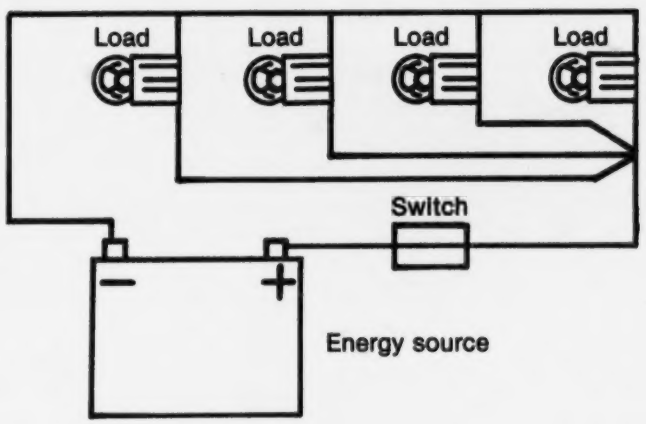
(a) Series circuit (b) Parallel circuit

Series-parallel circuit (Figure 4)

EXAMPLE: Battery connections for starting large vehicles such as buses and trucks

- Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel paths of the circuit
- Should an open occur in the path in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths of the parallel portion of the circuit, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

FIGURE 4



Series-parallel circuit

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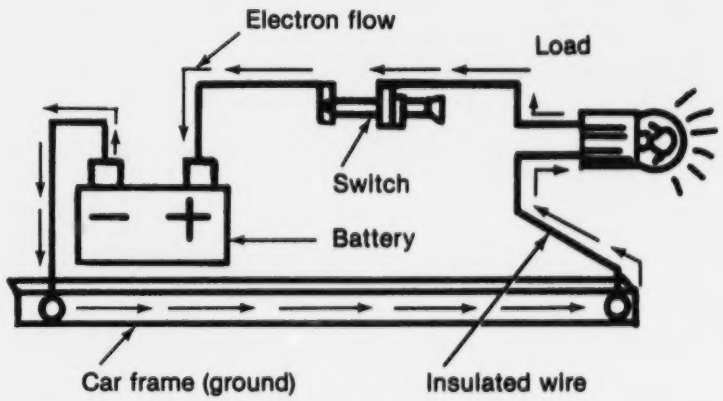
OBJECTIVE 7 | **Explain how a single-wire circuit functions**

Single-wire-circuit function — Circuit uses vehicle's frame as a part of the circuit: electrons flow from negative battery terminal through frame, through load, back along insulated wire, through switch, and then to positive battery terminal

The Frame Is the Conductor

The circuits you have studied thus far have all been similar in that they have contained at least two wires—one leading from the energy source (the battery) to the load and one from the load back to the energy source.

In a vehicle with a metal frame, it is not necessary to have a two-wire circuit—the vehicle's frame can be used in place of one wire in a circuit. To create such a circuit, the negative battery terminal is connected to the vehicle's frame. The positive terminal is connected to the load with an insulated wire. The pathway created through the vehicle's frame is called a *ground*. See the illustration below.



NOTE: Before 1956, some domestic vehicles had the positive battery terminal connected to the vehicle's frame; however, in 1956, it became standard on all domestic vehicles to connect the ground to the negative terminal.

OBJECTIVE 8

Recognize descriptions of types of electrical-circuit problems

Open circuit — Condition caused by a break in a circuit, causing current to stop flowing through the circuit

NOTE: Open circuits are a problem because they create a dead circuit. They are commonly caused by a loose connection or a broken wire, or by a blown fuse or fusible link. See the next objective for a definition of *fuse* and *fusible link*.

Short circuit — Condition caused when current bypasses a part of an intended circuit, causing current to flow in an accidental circuit

NOTE: There are two types of short circuits: wire-to-wire shorts (see Figure 5[a]) and short-to-ground (see Figure 5[b]). Both types of short circuits are problems because they cause fuses, fusible links, or circuit breakers to open a circuit.

- Wire-to-wire short circuit — Condition caused when a conductor in an intended circuit touches a conductor in another circuit, causing current to flow in the other circuit and power a different load
- Short-to-ground circuit — Condition caused when a conductor in an intended circuit touches a ground connection, creating an accidental ground

EXAMPLE:

FIGURE 5

Two types of shorts

(a) Wire-to-wire short **(b) Short-to-ground**

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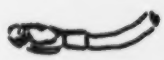
High-resistance circuit — Condition usually caused by a loose or badly corroded connection, causing a reduction of current flowing in a circuit

Causes of High Resistance

A common example of a high-resistance circuit can be detected by noting the changes in headlight brilliance commonly called *flare*. Flare is generally caused by a loose or corroded connection in the ground circuit or at a terminal. See illustration (a) below. This high resistance reduces current flow. As a result, the headlights appear relatively dim when the engine is idling, but flare noticeably when the alternator electrical output increases with engine speed. See illustration (b) below.

A high resistance can also occur internally in an electrically operated device. Remember, a high resistance reduces the current in a circuit, and in turn, also causes other loads in that circuit to operate at reduced power.

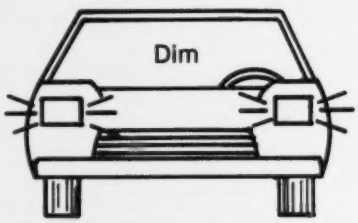
Whenever high resistance exists, lights will glow dimmer, motors will run slower, and in extreme cases, high resistance may act exactly like an open-circuit condition. For example, if a ground terminal becomes excessively corroded, its resistance—which is designed to be zero—may become so high that none of the loads in the circuit will operate at all.



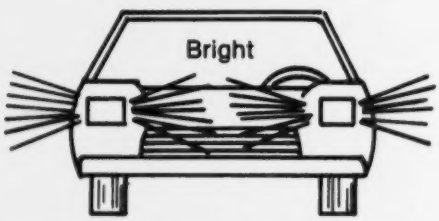
Corroded ground

Corroded battery connection

(a) Loose or corroded connections



Engine running at idle speed



Engine running at increased rpm

(b) High resistance to electrical circuit causes headlights to flare

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OBJECTIVE 9

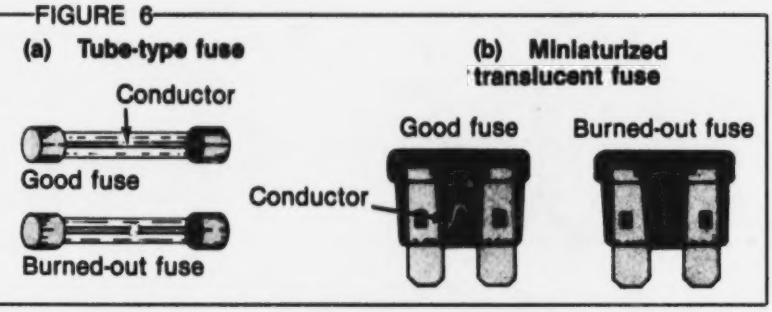
Recall types of circuit-protection devices and their functions

NOTE: Circuit-protection devices protect electrical circuit components from damage in case a short develops in the circuit. If a short should occur, excessive amounts of current flow through the circuit—amounts that could damage or even destroy circuit components. Protection devices are designed to create an open in the circuit to stop current flow and prevent component damage.

Fuse (Figure 6) — Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that soft-metal conductor melts (burns out) and permanently opens circuit when excessive current flows through it

NOTE: To close the circuit, a burned-out fuse must be replaced after the short has been eliminated from the circuit.

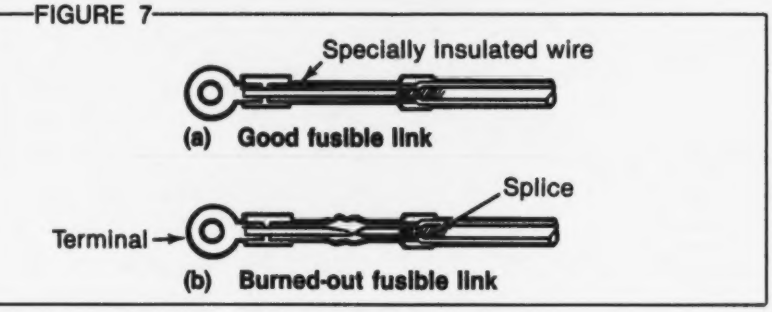
FIGURE 6



Fusible link (Figure 7) — Specially insulated wire connected in circuit; designed so that insulation puffs and smokes and then wire melts and permanently opens circuit when excessive current flows through it

NOTE: To close the circuit, a burned-out fusible link must be replaced after the short has been eliminated from the circuit.

FIGURE 7



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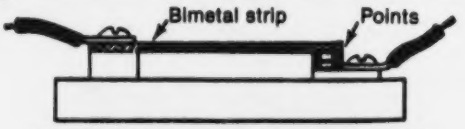
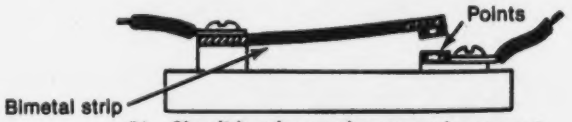
Circuit breaker (Figure 8) — Device containing a bimetal strip and a set of points; designed so that when excessive current flows through it, bimetal strip bends away from contact points and temporarily opens circuit until strip cools and again touches contact points

NOTE: Circuit breakers do not burn out when there is a short in the circuit. Therefore, it is not necessary to replace a circuit breaker after the short has been eliminated from the circuit.

FIGURE 8

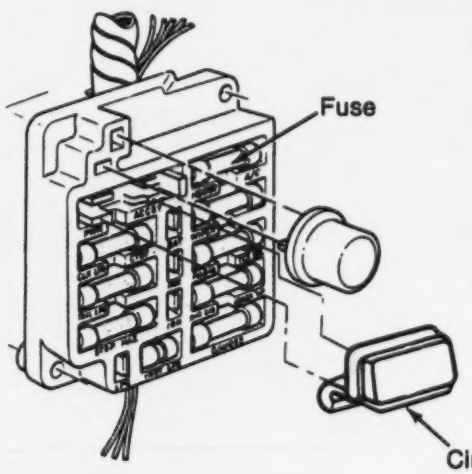


(a) Circuit breaker carries normal current; bimetal strip contacts points. Circuit is closed.



(b) Circuit breaker carries excessive current; bimetal strip bends away from points. Circuit is open.

Electrical Blocks



Typical fuse block or panel

Fuses and circuit breakers for major circuits are often grouped in a panel called a *fuse block* or *fuse panel.* Fuse blocks are usually located under the dash near the headlight switch, but may be placed elsewhere under the dash or in the glove compartment or in the engine compartment. The illustration to the left shows a typical fuse block utilizing tube-type fuses and a circuit breaker.

1306

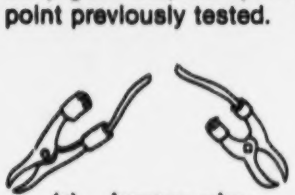
OBJECTIVE 10 | **Determine correct uses for electrical test equipment**

Jumper wires — Used for bypassing a portion of a circuit

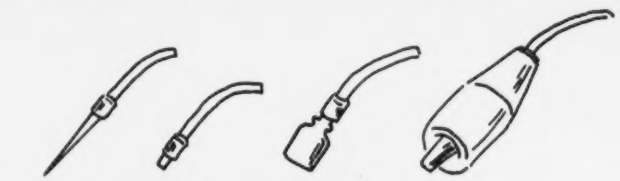
Simple—But Valuable—Tools

Jumper wires are simple yet extremely valuable pieces of test equipment. The simplest type of jumper wire is a length of multistrand wire with an alligator clip at each end. See illustration (a) below. Generally, electrical service specialists fabricate their own jumper wires. The well-equipped specialist will have several different types of jumper wires in several different lengths and with several types of tips. See illustration (b) below. Some jumper wires are made with three or more terminals coming from a common splice for special-purpose testing. In cramped, hard-to-reach areas, it is advisable to have insulated boots over the jumper-wire terminals in order to prevent accidental grounding, sparks, and possible fire.

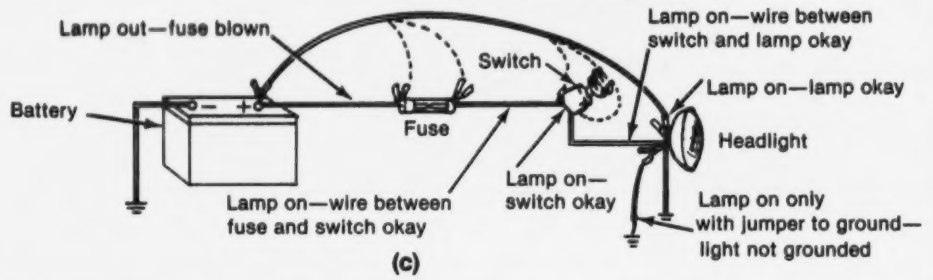
Jumper wires are used primarily to locate open circuits in either the ground side of the circuit or on the side between the energy source (battery) and the load (clamp). Refer to illustration (c) below. If the lamp fails to operate, connect the jumper wire as shown, between the lamp and a good ground. If the lamp operates only with the jumper installed, the lamp ground circuit is open. If the lamp ground circuit is good but the lamp does not operate, the circuit between the battery and lamp is open. You can then connect the jumper wire directly from the battery to the lamp terminal. If both the battery and the lamp are okay, the lamp will light. By moving the jumper wire back from the lamp toward the battery until the lamp goes out, you can isolate the area of the circuit where the open is located. When the lamp goes out, the open is in the segment of the circuit between the jumper wire and the point previously tested.



(a) Jumper wire



(b) Terminal tips



(c)

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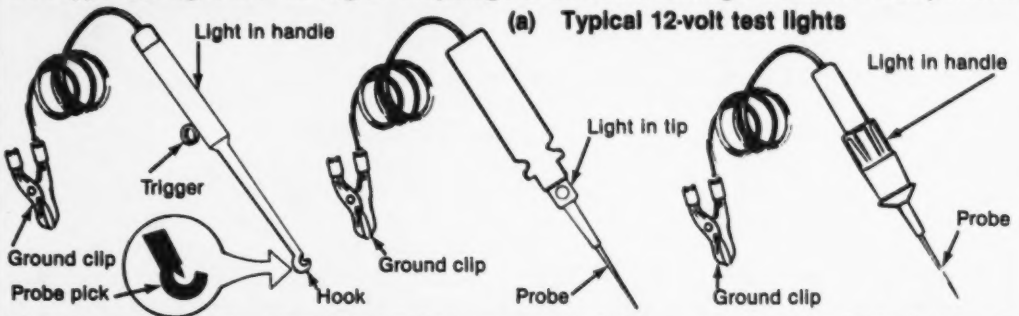
Test light — Used for checking to see that voltage is present in a circuit

Twelve-Volt Test Light

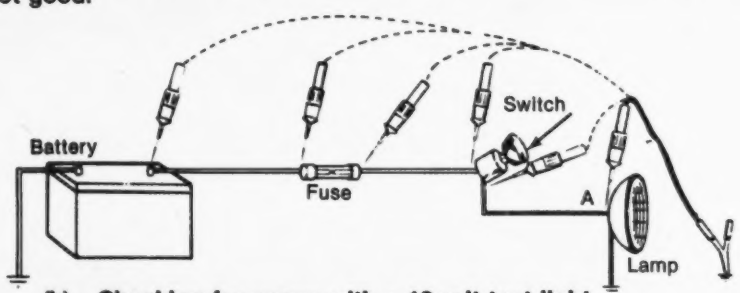
There are two types of test lights: 12-volt and self-powered. The 12-volt type is discussed below. The self-powered type is discussed on the following page.

A 12-volt test light is another easy-to-use piece of test equipment. Twelve-volt test lights come in different styles but all have three main parts: a ground clip, a probe, and a light. See illustration (a) below. The most commonly used 12-volt test lights have a pick-type probe. Two types of lights are used on these test lights. One type uses a number 67 bulb that draws 1.2 amps; the other uses an LED, which uses no more than 20 milliamps. The LED-type test light must be used when you are testing circuits with electronic components. Using the bulb-type test light with its higher amperage draw could damage electronic components.



(a) Typical 12-volt test lights

Like a jumper wire, the 12-volt test light is used to isolate opens in circuits. But whereas the jumper wire is used to bypass the open to operate the load, the 12-volt test light is used to locate the presence of voltage in a circuit. In the example shown in illustration (b), if the test-light probe is at point A and the light in the handle glows, you know that there is power up to the lamp; therefore, if the lamp does not operate normally, either it is burned out or its ground is not good.



(b) Checking for opens with a 12-volt test light

If the test light does not glow when its probe is at point A, you know that there is an open circuit between the battery and point A. Then, just as you do with a jumper wire, you can back toward the battery until the light in the handle glows. When it does, the open is between the probe and the point previously probed.

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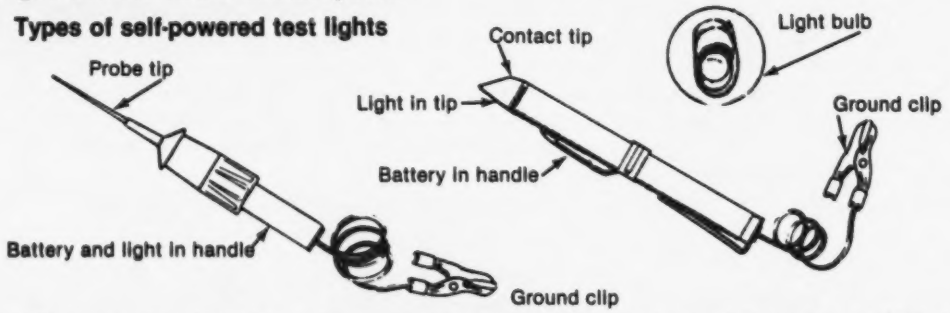
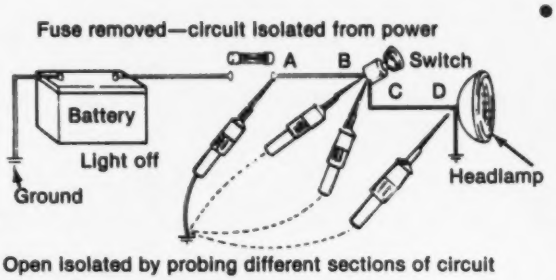
Self-Powered Test Light

The self-powered test light is, as its name implies, self-powered by a 1 ½-volt pen-light battery. Two types of self-powered test lights are shown in illustration (a) below. One type is similar in design to the 12-volt test light. This type has both the battery and the light in the handle and a pick-type probe tip. The second type has the light toward the open tip, so that the light illuminates the contact point.

(a) Types of self-powered test lights

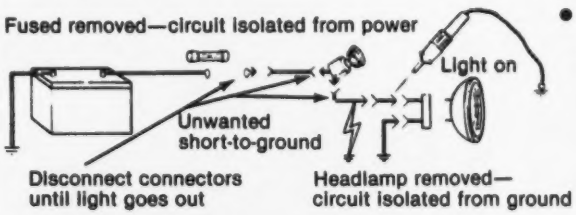


The self-powered test light is a dual-purpose piece of test equipment. It can be used to test either open or short circuits when power is isolated from the circuit.



(b) Checking for open circuits with a self-powered test light

- By using the test light as shown in illustration (b), you can check for open circuits. To do so, isolate the circuit from power, connect the test-light ground clip to a good ground, and probe sections of the circuit sequentially with the test light. If the light is out, the open is between the probe and the circuit ground. If the light is on, the open is between the probe and the end of the circuit toward the power source.



(c) Checking for short circuits with a self-powered test light

- By isolating the circuit both from power and from ground, as shown in illustration (c) you can check for shorts-to-ground in the circuit. Isolate the circuit from power to ground, connect the test-light ground clip to a good ground, and probe any easy-to-reach test point in the circuit. If the light comes on, there is a short somewhere in the circuit.

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Multimeter — Used for measuring voltage, current, and resistance

Three Instruments in One

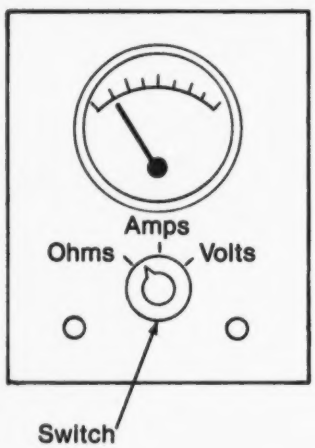
A **multimeter** (VOM) combines the functions of three types of test instruments into one. To understand the multimeter, you must first understand the function of each of these three test instruments: the voltmeter, ammeter, and ohmmeter.

A **voltmeter** measures the amount of electrical pressure (voltage) present in a circuit. A voltmeter is connected in parallel to a circuit and the circuit is powered when the measurement is taken.

An **ammeter** measures the amount of current (amperes) in a circuit. There are two types of ammeters: conventional and inductive. Conventional types must be connected in series with the circuit. Inductive types are simply slipped over the outside of the wire insulation in the circuit; this type of ammeter uses the magnetic field around the outside of the wire to determine the amperes in the wire.

An **ohmmeter** measures the amount of resistance (ohms) in a circuit. When an ohmmeter is used, the circuit is not powered, and the ohmmeter is connected in parallel.

As previously stated, a multimeter is a voltmeter, ammeter, and ohmmeter combined into one test instrument. There are two types of multimeters—digital and analog (an analog multimeter is shown in the illustration at right)—but each has a switch that can be used to change the meter function from amperes to ohms or to volts. When switched to one of the three functions, the multimeter must be connected to the circuit as described above for each type of meter.



1310

OBJECTIVE 17

Explain principles of battery operation during charging, discharging, and recharging

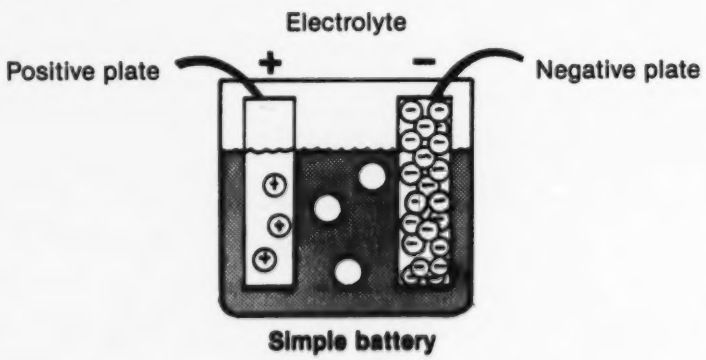
Charging (See Figure 9)

1. Two plates made from dissimilar conductors (lead peroxide and spongy lead) are placed in a sulfuric-acid-and-water solution called *electrolyte*
2. Acid attacks lead-peroxide plate (positive plate), releasing electrons that are attached to spongy-lead plate (negative plate)
3. Negative plate becomes full of electrons—the battery is charged

   NOTE: When the battery is charged, it is said to have *potential* (voltage).

   EXAMPLE:

FIGURE 9



Simple battery

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Discharging (See Figure 10)

1. Battery circuit is closed
2. Potential (voltage) causes electrons to flow through circuit to load, pulling electrons away from negative plate
3. As electrons are pulled away from negative plate, plates become similar in composition and acid in electrolyte decreases

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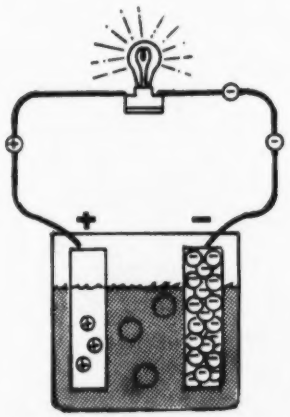
4. As positive and negative plates become more similar, battery voltage decreases—battery becomes weaker and will eventually be discharged if the battery is not recharged

   EXAMPLE:

FIGURE 10



A battery supplies electrons to power a light bulb

Used with permission of Glencoe Publishing Co., Inc., from *Auto Mechanics* by Jay Webster, copyright © 1980.

Recharging

1. Direct current is forced through battery (from alternator or battery charger), supplying electrons to positive plate, making positive and negative plates become dissimilar again and building up acid in electrolyte

2. Again the acid in the electrolyte attacks positive plate and electrons go to negative plate—the battery returns to a charged condition

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OBJECTIVE 18

Recall safety practices to follow when working with batteries

- Always wear safety glasses, rubber gloves, and a rubber apron when working with batteries

  NOTE: When working with batteries, you always run the risk of coming into contact with the acid inside the battery cells. This acid—called *electrolyte*—is strong enough to destroy clothing and burn eyes and skin. Always protect yourself from possible electrolyte burns by wearing the protective equipment listed above.

- Use fender covers to protect vehicle finish and metal surfaces from accidental electrolyte spillage

- Always keep a mixture of baking soda and water nearby when working with batteries

  NOTE: If electrolyte is accidentally spilled or splashed on clothing or skin, wash the exposed clothing or skin with the baking-soda-and-water solution, and then rinse with clean water. If electrolyte is spilled or splashed on a vehicle's metal surfaces, wash the exposed surface with the solution and then rinse with clean water.

- Do **not** smoke near a battery on charge or recently charged

  NOTE: When batteries are being charged, a gas forms in the battery cells. Some of this gas escapes through the battery's vent holes, forming an explosive atmosphere around the battery that can remain for several hours after the charge. Flames can ignite the gas around the battery, causing an explosion.

- Do **not** break live circuits at battery

  NOTE: A spark usually occurs at the point where the circuit is broken—this spark can also ignite the gas that forms around a battery.

- When disconnecting battery cables, always disconnect grounded-terminal cable clamp (negative cable) first, and when reconnecting cables, always reconnect insulated-terminal cable clamp (positive cable) first

  NOTE: Disconnecting and reconnecting battery cables incorrectly is a common cause of electrical arcs that cause battery explosions.

- When using a battery charger, make connections before plugging charger into power supply

- **Never** lay any conductor across battery terminals

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- Do **not** attempt to jump-start a battery that may be frozen

  NOTE: When temperatures are below the freezing point, electrolyte in a discharged battery can freeze. Attempting to jump-start a frozen battery can rupture the battery or cause it to explode. You must bring the battery temperature above the freezing point before attempting a jump-start.

- When connecting jumper cables to battery, always connect ground to vehicle frame or engine away from battery

- **Never** charge, test, or jump-start a sealed battery when hydrometer appears clear or light yellow

- **Never** wear metal rings or jewelry near battery

  NOTE: The heating of the metal can cause severe skin burns.

It Could Never Happen to Me

Batteries can be hazardous to your health...and your hair. One of our mechanics got a little preoccupied and forgot to make sure the battery charger was turned off before he attempted to hook it up. When he made the connection, a spark caused the battery to explode, spewing acid over the car and himself. Forgetting about himself for the moment, he hurriedly washed down the car for fear the acid would ruin the paint job. Afterwards, he washed himself off and changed into some spare clothes he kept handy. The next day, however, he showed up with a considerably shorter haircut. In his haste, he had neglected to rinse his hair thoroughly, so when he had combed his hair that afternoon, he found he had some noticeable holes. With some embarrassment, he explained that he decided a shorter hairstyle was preferable to a patchy one.

Kay O'Cullane, San Diego
Community Skill Center

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SUPPLEMENT 1

Vehicle Manufacturers' Schematic Symbols

INTRODUCTION

Today's automobiles and trucks contain many electrical devices—headlamps, parking lamps, radios, tape decks, garage-door openers—as well as electrical systems—charging system, starting system, ignition system. The basis of each electrical device and system is an electrical circuit. As the number of electrical systems has become more complex, the number of electrical circuits in each vehicle has become so vast that vehicle manufacturers had to provide specialists with *road maps* for locating specific electrical circuits and identifying circuit components when they require repair.

Wiring diagrams are the road maps used in electrical repair. Wiring diagrams present information symbolically. Just as the symbolic information on a road map will guide you in travel when you understand the symbols for towns and cities and their connecting roadways, the symbolic information on a wiring diagram will guide you through electrical repair when you understand the symbols for electrical-circuit components and their conductors.

As you have learned, a basic electrical circuit consists of the following components: an energy source, a switch, conductors, and a load. And you have studied that circuit protectors, resistors, and grounds are other common automotive electrical-circuit components. The symbols used in a simple wiring diagram contain the following information about these circuit components:

1. The location and relationship of the electrical components in a circuit.

2. The location of connections and splices in a circuit.

The location and relationship of the electrical-circuit components within a circuit are shown through the use of two types of electrical symbols: pictorial and schematic. Pictorial (representational) symbols are simplified illustrations of circuit components looking enough like the actual components that they can be readily recognized by someone familiar with the components. See Figure 1 (a) on the following page.

Schematic symbols are much more simplified, stylized drawings that may need to be memorized so that they can be recognized. See Figure 1 (b) on the following page.

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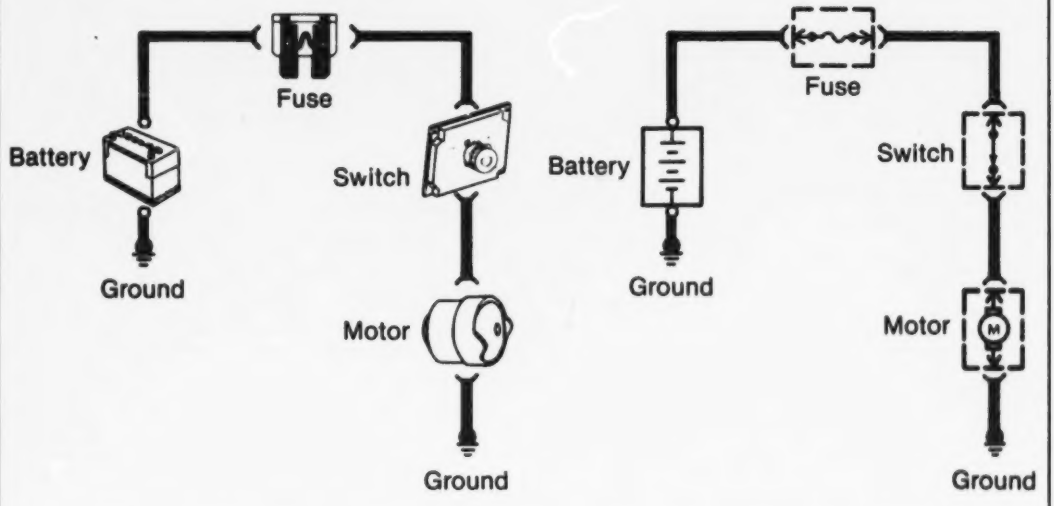
FIGURE 1



(a) Pictorial wiring diagram (b) Schematic wiring diagram

Used with permission of Ford Motor Company.

Some manufacturers do not use pictorial symbols in their more complex wiring diagrams; others do. Since some manufacturers do not use them and since pictorial symbols are usually labeled and easily recognizable anyway, they will not be covered here. However, because all manufacturers use some schematic symbols and a knowledge of them is critical to the easy and fast reading of wiring diagrams, basic schematic symbols must be learned and are presented below and on the following pages in Table 1.

TABLE 1: Schematic symbols

Symbols indicating the location of conductors, connections, and splices
Conductors are the wires or metal components that connect all the circuit components and provide the path for current flow. The symbol for a conductor is shown below.
Conductor

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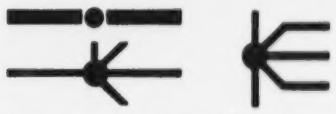
The locations of electrical **splices** and **connections** in circuit conductors are indicated by a black dot where the conductors are joined. See Figure (a) below. Conductors that cross but are **not** connected do not have a black dot where the conductors cross. See Figure (b)



(a) Spliced or connected conductors

(b) Crossed but not connected conductors

Symbols indicating the location of connectors

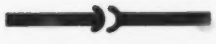
A **connector** is used to attach a conductor to another conductor or component. Connectors are referred to as *male* or *female*, as shown by the symbols below.

Male

Female

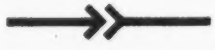
The following symbols are representative of connector symbols used by General Motors, Ford, and Chrysler.

GM



Ford

Chrysler



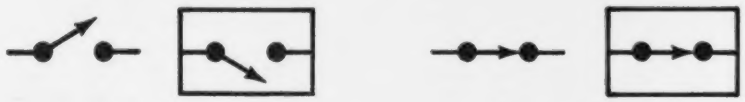
Symbols indicating the location of energy sources

The **storage battery** provides the electrical power needed to start a vehicle and to operate all electrical systems during key-on/engine-off modes.

The symbols below are representative storage-battery symbols.

Symbols indicating the location of switches

The simplest type of switch, called a **single-pole/single-throw (SPST) switch**, opens and closes an electrical circuit with a single conductor. The symbols for this type of switch are shown below.

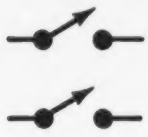


Switch open Switch closed

The symbols below show a **single-pole/double-throw (SPDT) switch**, which is used to alternately control two circuits.

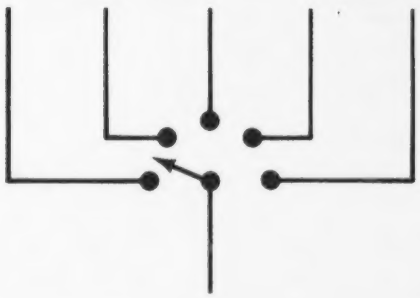
Switch open

A **double-pole/single-throw (DPST) switch** combines the function of two single-pole switches with multiple sets of contacts in a single switch.



Switch open

When one of several loads must be selected by the switch, a **rotary switch** is used. The symbol for a rotary switch is shown below.

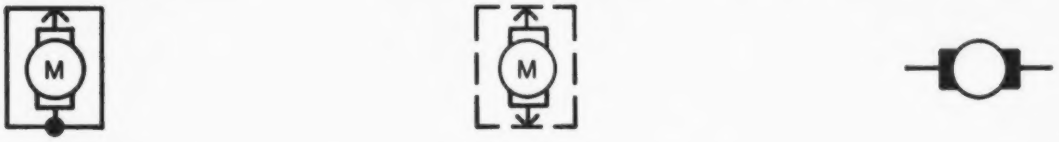


Symbols indicating the location of load devices

A **load** is a circuit component that converts electrical energy to some other form of energy. Common automotive loads are horns, gauges, motors, lamps or bulbs, and resistors.

Lamp symbols

Motor symbols



Gauge symbols

Horn symbols

Resistors

When it is necessary to add resistance to a circuit to intentionally reduce the flow of current in a circuit, the required resistance is usually provided through the use of a **resistor**, a load that converts electrical energy to heat.

Two types of resistors are used in automotive electrical circuits: fixed and variable. The variable resistor is adjustable, and the adjustable feature is shown by drawing an arrow across the symbol.

Fixed resistor

Variable resistor

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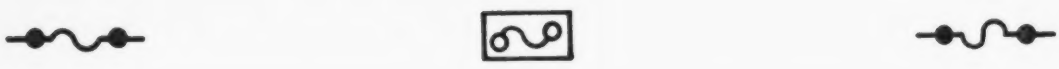
Symbols indicating the location of circuit-protection devices

Automotive circuits and their loads are protected from possible electric overloads by circuit components called **circuit-protection devices**. Common circuit-protection devices are fuses, fusible links, and circuit breakers.

Fuse

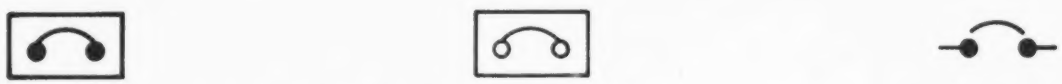


Fusible link

(a) (b)

NOTE: Fusible links in Ford wiring diagrams are labeled as "fuse link" and given a numerical code indicating the circuit number. See Figure (b) above.

Circuit breakers



Symbols indicating the location of grounds

Most automotive circuits use the metal parts of the vehicle's frame to form the circuit's pathway back to the power source. This return pathway, which is called the **ground**, is depicted by the following symbols.

GM **Ford** **Chrysler**

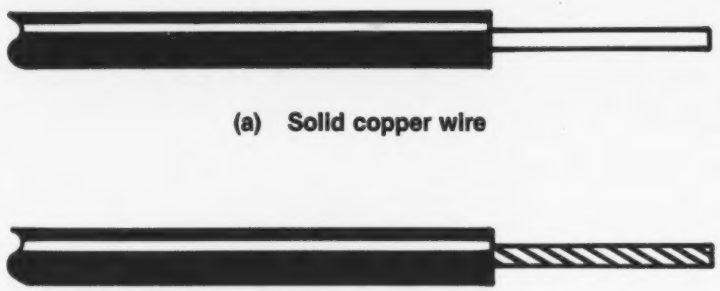
SUPPLEMENT 2

Automotive Wiring

INTRODUCTION

Although you probably normally think of a wire as being a solid piece of copper covered with insulation (see Figure 1 [a]), most wiring used to connect the components of automotive circuits is made of stranded copper wire. Stranded wire—wire made up of many thin strands (see Figure 1 [b])—is used because it is more flexible than solid wire. Solid wire is subject to metal fatigue and, under the severe vibration possible in automotive circuits, would break. Therefore, although some solid-copper wire is used in automotive circuits, its use is often limited to the internal wiring of certain circuit components (solenoids, alternators, and motors) and on printed circuit boards—places where the current requirements are low and wire flexibility is not essential.

FIGURE 1



(a) Solid copper wire

(b) Stranded copper wire

Other types of wire used in automotive circuits

- **Aluminum wire.** Solid aluminum wire is seldom used in vehicles because aluminum is a poorer conductor of electricity than copper and is even less flexible than solid-copper wire. However, as with solid-copper wire, aluminum wire is sometimes used where the current requirements are low and wiring flexibility is not essential.

- **Resistance wire.** Resistance wire is wire made to have a certain amount of resistance per foot and is used in certain circuits to limit current flow in circuit components.

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Wire sizes

The size of the wire to be used in a circuit is determined by how much current must be safely carried by the wire without causing overheating. The larger the wire's diameter, the greater the wire's current-carrying capacity. Therefore, circuits requiring large amounts of current use wire larger in diameter and circuits requiring less current use wire smaller in diameter.

The size of a wire's diameter—called its *gauge*—is measured in units called *mils* (one-thousandth of an inch) or in *circular mils* (the cross-sectional area of the wire, or the square of the wire's diameter). Gauge sizes have been standardized in domestic vehicles into American Wire Gauge (AWG) sizes. Table 1 below shows the AWG sizes and diameters most commonly used in automotive circuits. Note that the higher the gauge number of a wire, the smaller is the diameter of the wire.

Table 1: AWG wire gauges

Wire size (gauge)	Wire diameter (mils)	Wire cross-sectional area (circular mils)
20	32.0	1,020
18	40.3	1,620
16	50.8	2,580
14	64.1	4,110
12	80.8	6,530
10	101.9	10,380
8	128.5	16,510
6	162.0	26,240
4	204.3	41,740

The wire used in most imported cars and some newer domestic cars is measured in metric units. In the metric system, wire size is expressed in square millimeters (mm^2). A conversion chart, see Table 2, shows the equivalent wire sizes for the AWG and metric systems.

Table 2: Metric conversion chart

AWG wire size (gauge)	Metric wire size (mm^2)
20	0.5
18	0.8
16	1.0
14	2.0
12	3.0
10	5.0
8	8.0
6	13.0
4	19.0

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Insulation

As you have learned, wiring used in electrical circuits is surrounded with a protective covering—insulation. Insualtion, like wires, also comes in different thicknesses according to the current-carrying requirements of a particular circuit.

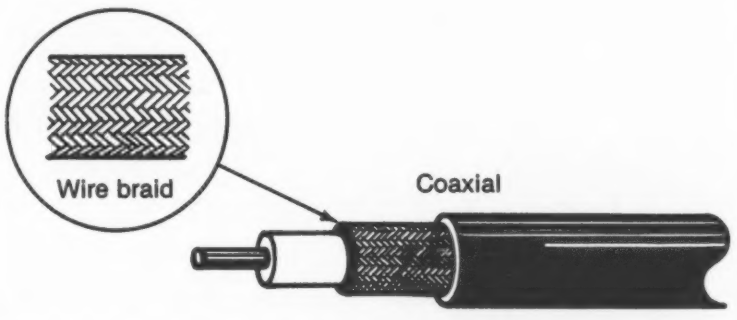
- The voltage carried by most of the wiring in a vehicle should not exceed 16 volts. Therefore, most wires require only a thin plastic insulation unless they are to be located in an area of the vehicle where they will be exposed to high temperatures or other harmful conditions.

- Wire used in a vehicle's ignition system must be designed to carry much higher voltage. Therefore, ignition-system wiring requires a tough, temperature-resistant insulation.

- Wiring used in circuits connecting a vehicle's audio components, such as a radio, tape player, or citizen band radio, must be protected against the electromagnetic energy produced by sparks created in other automotive electrical circuits. An audio component can receive the electromagnetic energy from these sparks, which results in a buzzing sound called *spark interference*.

  To prevent spark interference from reaching the conductor in the center of the wire and being received by the audio components, the wire's central conductor is covered by a layer of insulation, which is covered by a braided conductive shield, which is covered by another layer of insulation. See Figure 2 below. This special type of insulated wire is called *shielded wire* or *coax* (coaxial cable).

FIGURE 2



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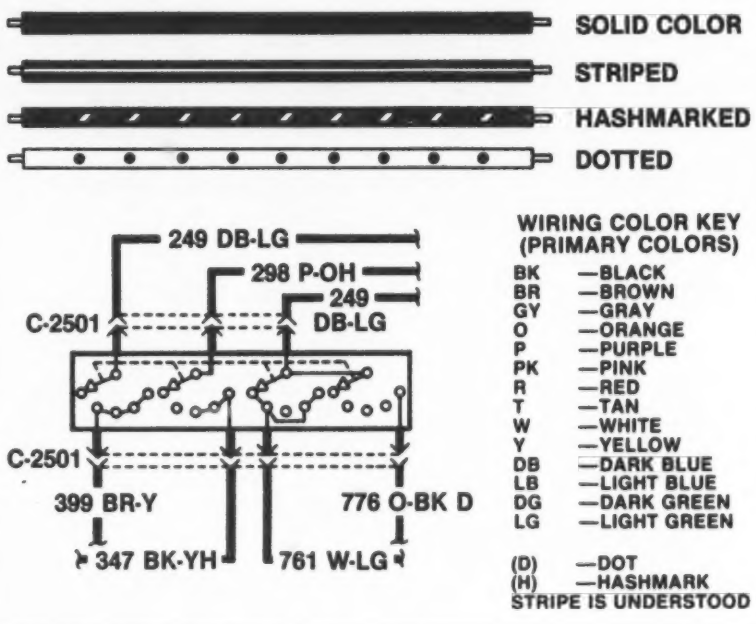
Wire Identification

Automotive manufacturers' wiring diagrams are especially useful in helping you identify replacement wire that may be necessary for circuit repair. In wiring diagrams, all wires are identified through the various coding systems used by the various automotive manufacturers. The major domestic manufacturers, for example, use the following coding systems.

- **Ford** identifies wires through the use of a wire-numbering/color-coding scheme. See Figure 3. On the wiring diagram, the number listed first represents the circuit number in which the wire is connected, the letters are abbreviations for the color codes used on the actual wires. For example, in Figure 3, 249 DB-LG indicates that in circuit number 249 this wire can be identified as the dark blue wire with a light green stripe. Circuit numbers and colors and gauge numbers for wiring in the circuits are cross-referenced in the introductory part of the wiring-diagram book.

FIGURE 3



Used with permission of Ford Motor Company.

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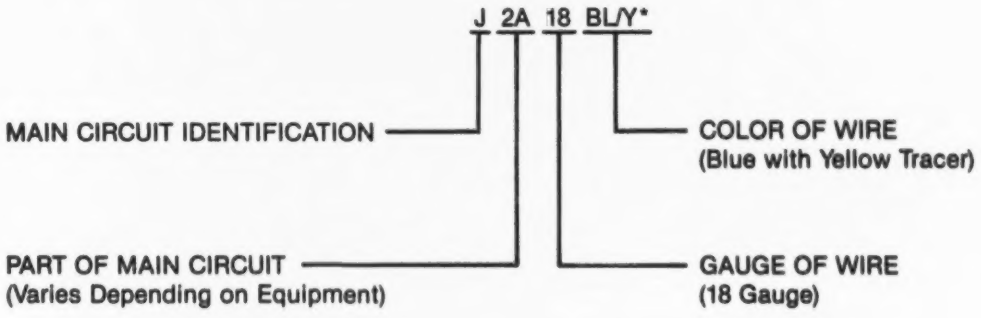
- **Chrysler** uses a similar wire-numbering/color-coding system. See Figure 4. The first letter in the code identifies the main circuit where the wire is located, the next number/letter combination is the code for the portion of the main circuit represented by the first letter, the wire gauge number is given next followed by the letter abbreviation identifying the color of the wire's insulation. For example, a wire labeled J 2A 18 BL/Y* can be identified as the 18-gauge blue wire with the yellow tracer in the 2A portion of main circuit J.

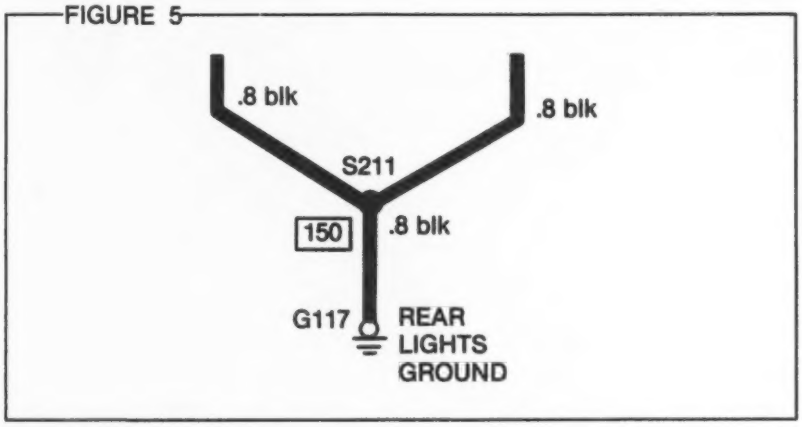
FIGURE 4



Used with permission of Chrysler Motor Corporation.

- **General Motors** wire-identification codes include the wire size in square millimeters, the color of the insulation, and the circuit number. See Figure 5. The codes here indicate that there is a black 0.8 mm^2 wire in circuit number 150.

FIGURE 5



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SUPPLEMENT 3

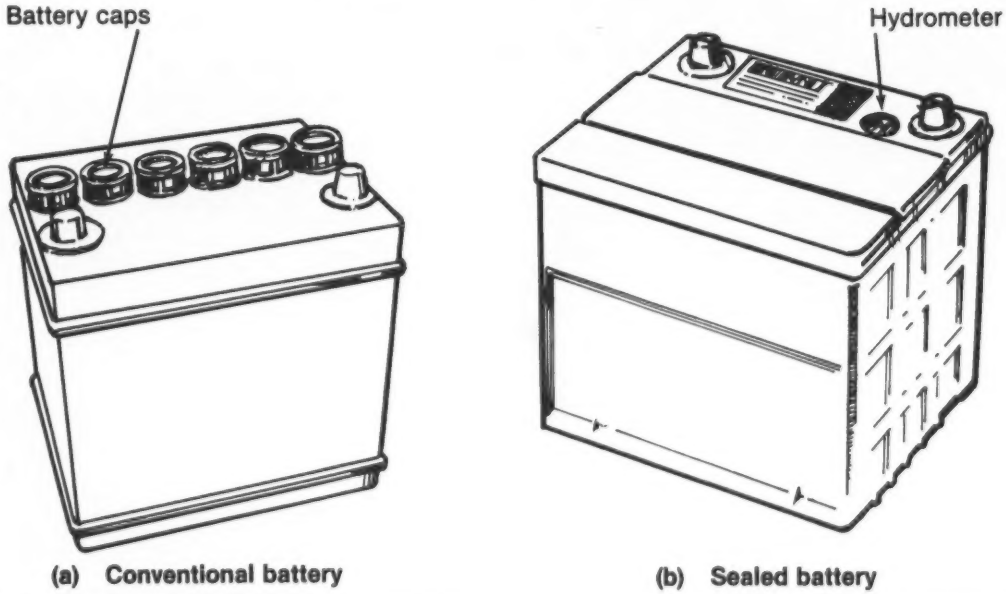
Battery Types

There are two basic types of batteries—conventional and sealed—and these two basic types come in two terminal-mount designs—top-mounted post-type terminals and side-mounted sealed terminals.

The **conventional battery** (see Figure 1 [a]) is composed of a case into which is placed a series of removable caps covering filler holes over the internal battery cells, each cell consisting of several plates covered by electrolyte—an acid-and-water solution (acid 40%; water 60%). Removable battery caps are required in this basic type of battery because the electrolyte level lowers with battery use and occasionally requires the addition of water to maintain proper electrolyte level.

Sealed batteries, also called *maintenance-free batteries*, (see Figure 1 [b]) are a newer battery type. These batteries can be sealed because the electrolyte in the battery cells does not require maintenance of the electrolyte level. Other battery-service requirements are indicated by the appearance of the sight glass located in the hydrometer built into the battery case.

FIGURE 1



(a) Conventional battery

(b) Sealed battery

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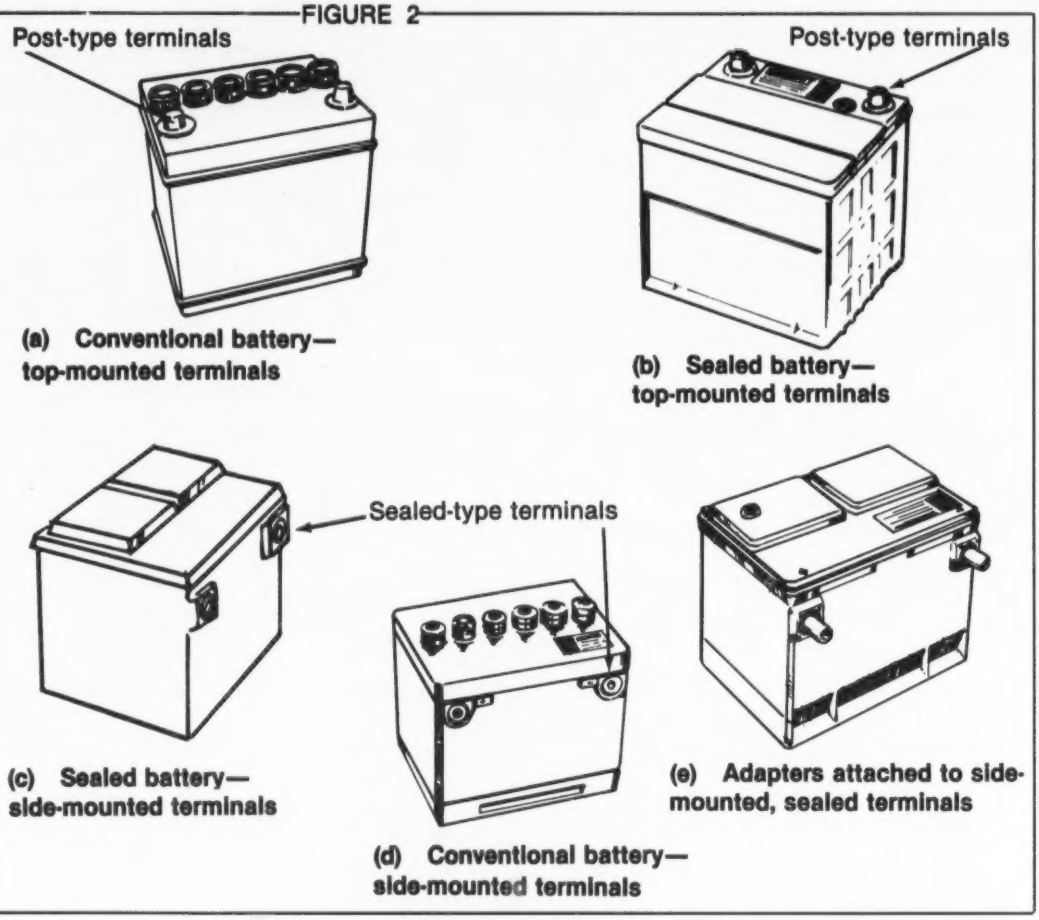
Both conventional batteries and sealed batteries come with either top- or side-mounted terminals (see Figure 2 [a], [b], [c], and [d]). **Top-mounted post-type terminals** make up the traditional design. The battery cells in this design are connected to each other by connectors with additional connectors at each end of the battery case, and these connectors are connected to positive and negative battery posts. Battery posts are most obvious when they are used during battery service such as charging and emergency jump-starting.

FIGURE 2



(a) Conventional battery—top-mounted terminals

(b) Sealed battery—top-mounted terminals

(c) Sealed battery—side-mounted terminals

(d) Conventional battery—side-mounted terminals

(e) Adapters attached to side-mounted, sealed terminals

Side-mounted sealed terminals are a new design that came into being to remove the terminals from the high-corrosion-prone top area of the battery. There are no battery posts with this terminal design and special adapters must be used to provide a good connection for battery cables and charging equipment during battery service (see Figure 2 [e]).

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SUPPLEMENT 4

Battery-Service Troubleshooting Chart

INTRODUCTION

To find out whether a battery—conventional or sealed—is functioning properly may require you to perform as many as four service procedures: (1) a visual inspection to determine whether the battery has sustained physical damage and therefore must be replaced, (2) a state-of-charge test to determine whether the battery requires recharging, (3) a slow-charge to bring the battery up to a state of charge that allows further testing, and (4) a load test to determine whether the battery is worn out and should be replaced. However, battery-service procedures are not often performed in a one, two, three progression. The service-procedure progression performed varies according to the battery type and/or the results determined at various stages in the progression. Therefore, while the battery-service job sheets provided in this unit will be helpful to you in learning the steps in each of these four battery-service procedures, the following troubleshooting chart must also be used to help you determine when it is necessary to perform what procedure on each type of battery.

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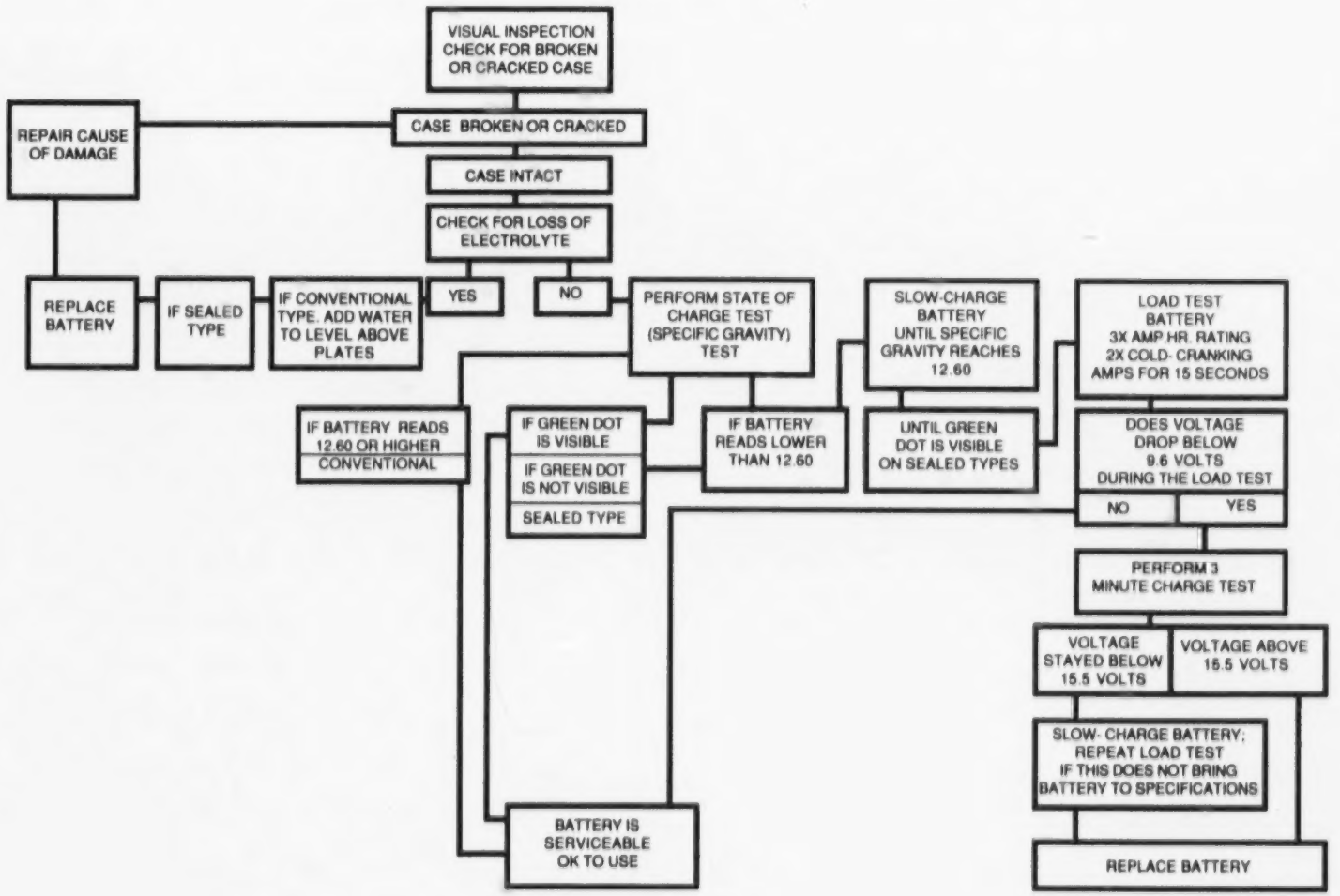
BATTERY -SERVICE TROUBLESHOOTING CHART


VISUAL INSPECTION CHECK FOR BROKEN OR CRACKED CASE
CASE BROKEN OR CRACKED
REPAIR CAUSE OF DAMAGE
CASE INTACT
CHECK FOR LOSS OF ELECTROLYTE
YES
NO
IF CONVENTIONAL TYPE. ADD WATER TO LEVEL ABOVE PLATES
IF SEALED TYPE
REPLACE BATTERY
PERFORM STATE OF CHARGE TEST (SPECIFIC GRAVITY) TEST
IF BATTERY READS 12.60 OR HIGHER
CONVENTIONAL
IF GREEN DOT IS VISIBLE
IF GREEN DOT IS NOT VISIBLE
SEALED TYPE
IF BATTERY READS LOWER THAN 12.60
SLOW-CHARGE BATTERY UNTIL SPECIFIC GRAVITY REACHES 12.60
UNTIL GREEN DOT IS VISIBLE ON SEALED TYPES
LOAD TEST BATTERY 3X AMP HR. RATING 2X COLD- CRANKING AMPS FOR 15 SECONDS
DOES VOLTAGE DROP BELOW 9.6 VOLTS DURING THE LOAD TEST
NO
YES
PERFORM 3 MINUTE CHARGE TEST
VOLTAGE STAYED BELOW 15.5 VOLTS
VOLTAGE ABOVE 15.5 VOLTS
SLOW- CHARGE BATTERY; REPEAT LOAD TEST IF THIS DOES NOT BRING BATTERY TO SPECIFICATIONS
BATTERY IS SERVICEABLE OK TO USE
REPLACE BATTERY

SUPPLEMENT 5

Battery Replacement

When the vehicle manufacturer installs a battery in a new vehicle, that battery has been carefully selected because its current output (capacity) meets the current requirements of the vehicle's engine design and of the electrical options installed in the vehicle. When you select a replacement battery for a vehicle, you must be equally careful to choose one that will meet the vehicle's current requirements. But with so many different batteries available, how do you know you are selecting the correct battery?

The Society of Automotive Engineers (SAE) and the Battery Council International (BCI) have established and standardized battery ratings to provide you with a means of determining the amount of current a battery can provide. The SAE and BCI establish these ratings—ampere-hour, reserve-capacity, and cold-cranking—through laboratory testing procedures that measure a battery's terminal voltage after a specified time period and discharge rate.

- **Ampere-hour rating.** A battery's ampere-hour rating is determined by measuring how much current (how many amps) a battery at 80 degrees F will deliver in a 20-hour period without terminal voltage dropping below 10.5 volts.

  The testing agencies determine the battery's rating number by multiplying the amperage delivered by 20. For example, if the battery is found to deliver 3 amps for 20 hours, it is assigned a 60-ampere-hour rating.

- **Reserve-capacity rating.** A battery's reserve-capacity rating is determined by measuring the length of time required to discharge a fully-charged battery (at 80 degrees F) at a rate of 25 amps until terminal voltage falls below 10.2 volts.

  The testing agencies developed this rating system to give the average person a more practical standard to use in comparing batteries. The rating, given in minutes, is the amount of time a vehicle can be driven before the battery is discharged after the vehicle's charging system fails. For example, a rating of 100 minutes means that once the charging-system failure-indicator lamp comes on, the driver has 1 hour and 40 minutes of driving time under minimum electrical load to get to a service facility before the battery is discharged.

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- **Cold-cranking rating.** A battery's cold-cranking rating is the rating most commonly used today. The rating is determined by measuring the amount of current (amps) a battery can deliver for 30 seconds at 0 degrees F and still maintain a terminal voltage of 7.2 volts. Typical ratings are 500, 525, and 625.

  The cold-cranking rating provides you with information to help in determining whether a battery has a sufficient amount of initial amperage available to crank a given engine at ambient (surrounding air) temperatures at or below freezing. This rating becomes extremely critical when you consider that at 32 degrees F a battery has less than 65 percent of the battery charge available for starting a vehicle and at 0 degrees F more than 60 percent of the battery's charge is lost.

  The rule of thumb used when applying this numerical rating is to select a battery with a cold-cranking rating that at least equals the cubic-inch displacement of the vehicle's engine. For example, you should select a battery with at least a 350-cold-cranking rating for a vehicle's engine with a 350-cubic-inch displacement.

Using battery ratings to determine replacement-battery requirements. Regardless of the battery rating used, you should choose a replacement battery with a rating at least equal to the battery installed as original equipment—or perhaps higher if the vehicle has been fitted with aftermarket electrical equipment, or if the vehicle is subjected to unusual service requirements, such as extremes in temperature.

1332

ASSIGNMENT SHEET 1

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 11

Interpret electrical values from various digital multimeter settings

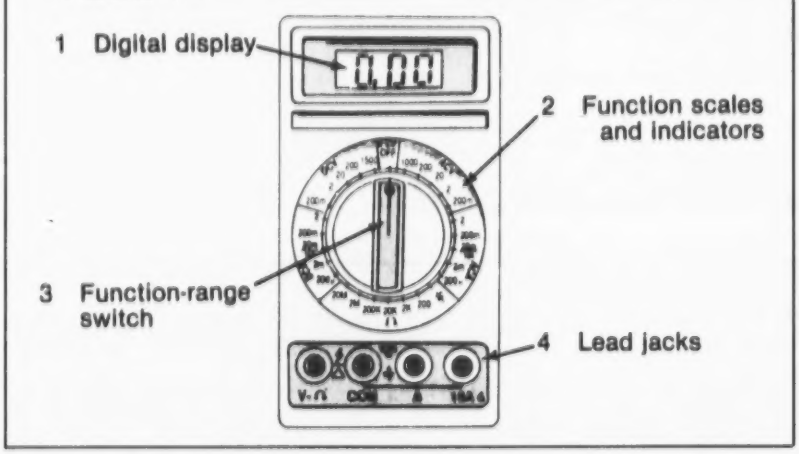
Name _____ Score _____

INTRODUCTION

There are two types of multimeters: digital and analog. In the past, the analog-type meter with a pointer that moves across a numbered scale was used for most automotive electrical testing. Then, electrical circuits were less complex and the analog reading was accurate enough for the purposes to which it could be applied. Today, however, vehicles contain computer inputs and outputs and electronic circuits where test results must be precise. Now, being able to use and read a digital multimeter is a must for all specialists because a digital meter's display can be read to within 0.1 percent—most people cannot read an analog meter to anywhere near that degree of accuracy. This assignment sheet will help you learn to read a digital multimeter; Job Sheet 3 will help you learn how to use a multimeter to measure current, voltage, and resistance.

A typical digital multimeter, such as the one illustrated in Figure 1, has four major areas: (1) a digital display, (2) function scales and indicators, (3) a function-range switch, and (4) lead jacks. When the meter is in use, the function-range switch is turned to one of the six meter scales or indicators, the meter leads are connected to the circuit under test, and then a reading appears on the digital display.

FIGURE 1



1333

To obtain a correct reading from the digital display, you must be aware of the purposes of each function-range scale or indicator. Using Figure 2 as a reference and reading clockwise on the illustration, match the various scales and indicators with their purposes given below.

1. The OFF indicator is used between testing procedures to conserve the meter's battery without completely turning the meter off at the power switch.

2. The ACV scale is used to check alternating-current voltage.

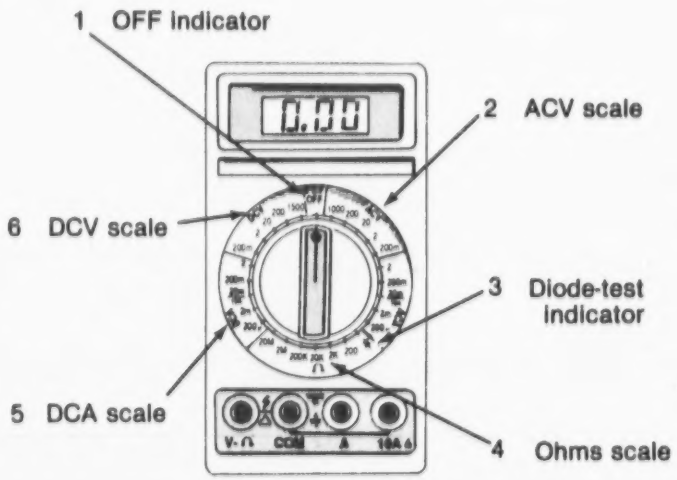
3. The ⊣◆⊢ symbol is the diode-test indicator, which is used to check diodes for shorts or opens.

4. The ohms scale is used to make accurate measurements of in-circuit resistance or of electrical components out of the circuit.

5. The DCA scale is used to check direct-current amperage.

6. The DCV scale is used to measure available voltage in direct-current circuits.

FIGURE 2



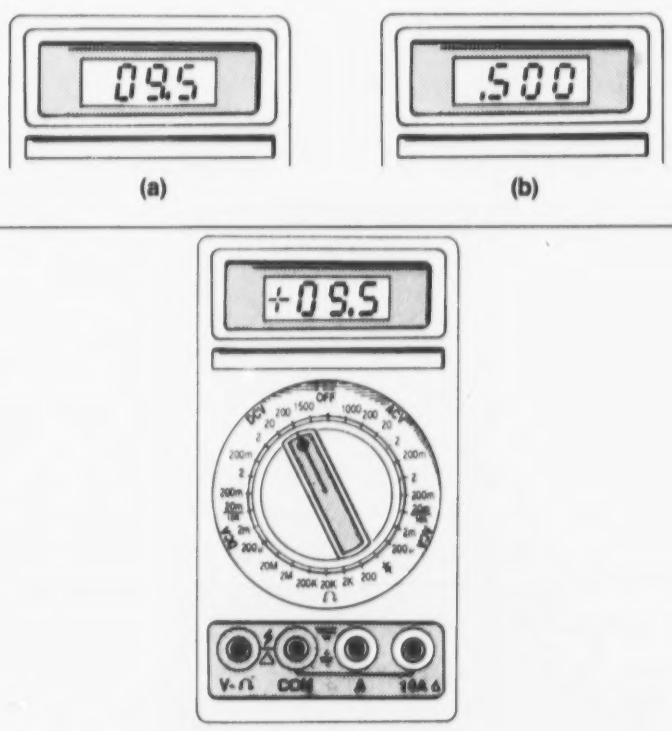
1334

Reading the digital display

Reading the digital display for **voltage** and **amperage** measurements is simple—the display is read directly, regardless of where the function-range switch is set on the scale. For example, see Figure 3 (a) and (b). When 09.5 appears on the display, as in Figure 3 (a), the display is read as "nine point five volts or amps," depending on the function-range-switch setting. Notice that the zero in front of the nine is ignored. When .500 appears on the display, as in Figure 3 (b), the display is read as "point five volts or amps," depending on the function-range-switch setting. Remember, the zeroes count only when they are between a number and a decimal point.

In the DCV function, a plus (+) or a minus (−) symbol will also appear to the left side of the readout (see Figure 3 [c]). These symbols indicate circuit polarity and are read as "volts positive" or "volts negative." For example, +9.5 is read as "nine point five volts positive."

FIGURE 3



1335

Reading the digital display for **ohms** is somewhat more complicated. On the ohms scale there are five range settings: 200Ω, 2KΩ, 20KΩ, 200KΩ, and 2000KΩ. The display for the 200Ω setting is the only ohms display that can be read directly. See illustration (a) in Figure 4. When 135 appears on the display at the 200Ω setting, the display is read as "one hundred thirty-five ohms." When the meter is at the 2KΩ, 20KΩ, 200KΩ, or 2000KΩ setting, some simple math must be done to obtain a correct reading. At 2KΩ, the reading must be multiplied by 1000 to obtain a correct reading; at 20KΩ, by 10,000; at 200KΩ, by 100,000; and at 2000KΩ, by 1,000,000.

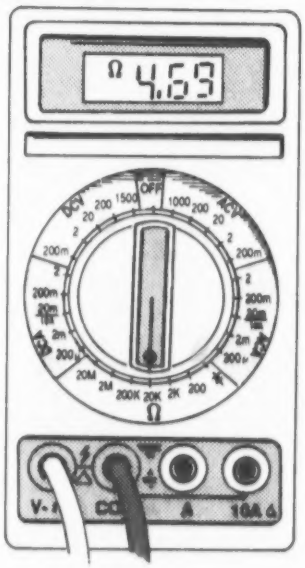
For example, when .135 appears on the display at the 2KΩ setting, the reading must be multiplied by 1000 (or the decimal must be moved over three places to the right) to obtain the correct reading of "one hundred thirty-five ohms" (see Figure 4 [b]).

FIGURE 4

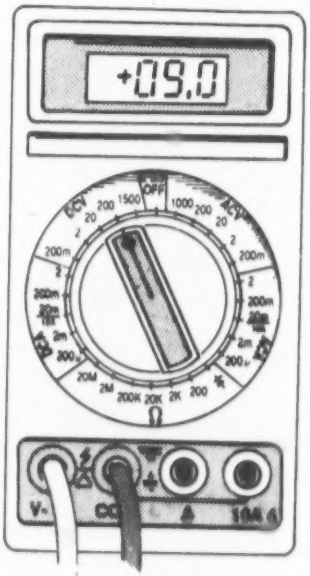
Meter display	Actual resistance
(a) 200Ω setting	135 ohms
(b) 2KΩ setting	.135 × 1000 = 135 ohms

DIRECTIONS

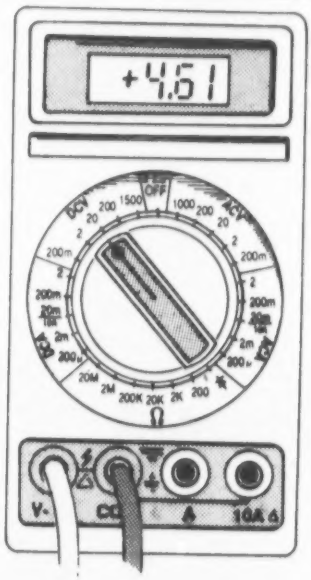
Study each of the digital multimeters illustrated below to determine the function-range setting, and then read the display for the meters. Write the correct meter reading on the blanks provided under the illustrations.



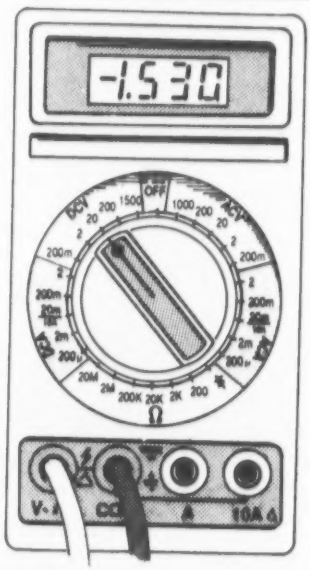
1. _____



2. _____

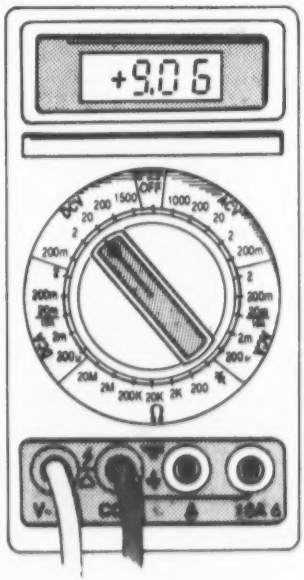


3. _____

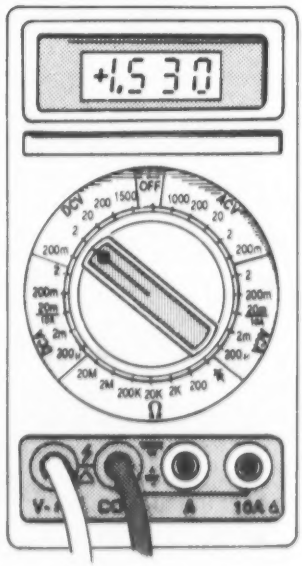


4. _____

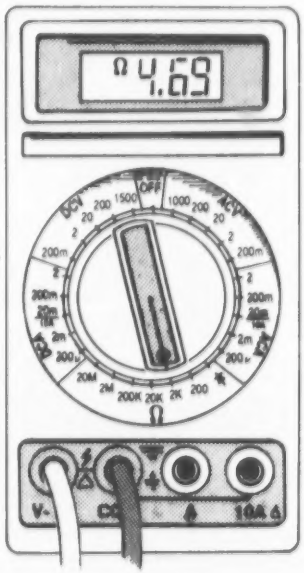
1337



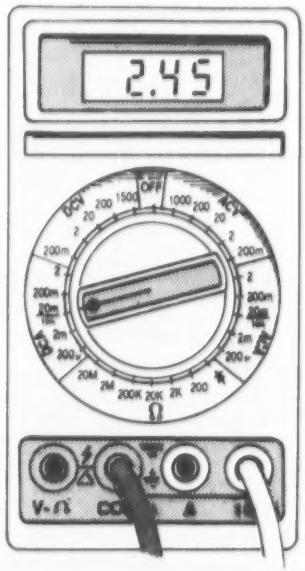
5. _____



6. _____

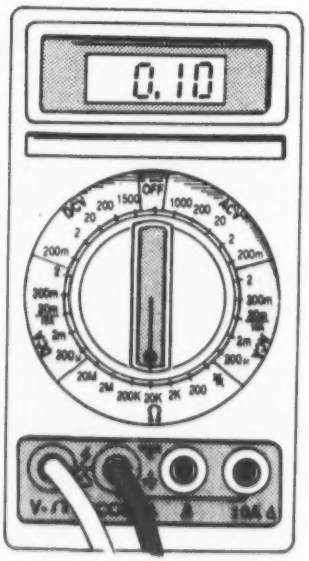


7. _____

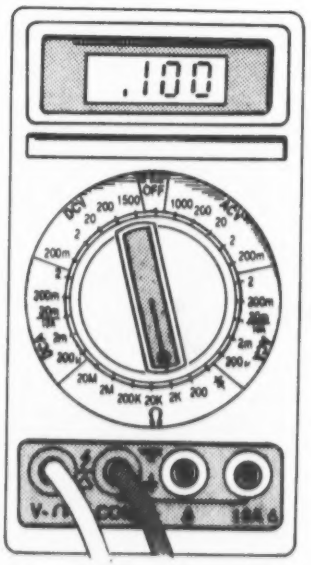


8. _____

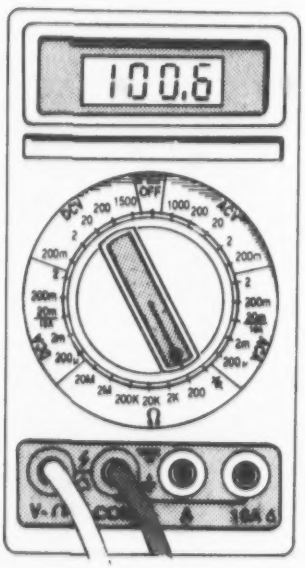
1338



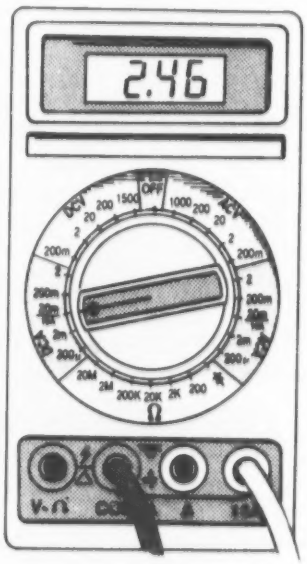
9. _____



10. _____



11. _____



12. _____

1339

ASSIGNMENT SHEET 2	APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 12

Interpret automotive-circuit wiring diagrams

Name _____ Score _____

INTRODUCTION

The purpose of this assignment and the exercises it contains is to provide you with exposure in reading automotive wiring diagrams. Diagrams are probably the most useful aid in automotive electrical work. However, the right diagram for a particular make, model, and year is not always easy to find and diagrams are presented in several different ways by the various manufacturers. Often, you will have to figure out the diagrams by yourself. This assignment will help you do this.

Reading diagrams. It is best to read a diagram by starting at the electrical source for a particular circuit and working outward to the end: in other words, just as electricity flows—from the high-voltage side to the low-voltage side. However, in some diagrams the circuit under study may be hard to find and may even appear on several different pages. Here it may be easier to work backward—that is, first finding the part and then working back toward the battery.

One line on a diagram equals one wire in the vehicle. Sometimes the diagram has a line that appears to dead-end in the middle of nowhere. Such lines often have numbers or letters (codes) next to them. These indicate that you are to pick up the same code elsewhere on the diagram and continue reading at that point. This avoids too much clutter and makes the job easier.

Factory diagrams are first drawn on big pieces of paper, sometimes taking up a whole wall, or walls. When done, pictures are taken with a camera and then reduced to a single page. Many of the newer vehicles have diagrams that take several pages. Sometimes the diagrams have been reduced so that they are so small that the lines are very close together. It is not unusual to have to read diagrams with a magnifying glass, using a straightedge and a pencil to mark a particular route. Although you may get lost and have to start over several times, remember that even a tiny diagram is better than no diagram at all.

Good diagrams will have numbers on all the lines. These numbers are gauge numbers, the size of wire that is used on the vehicle. Excellent diagrams use color codes for the wires. See Student Supplement 2, "Automotive Wiring," for an explanation of wiring codes.

Introduction and Part D of Assignment 2 from Don Westlund, *Automotive Electrical Reference Manual*, ©1983, pp. 121-127. Adapted by permission of Prentice-Hall, Inc., Englewood Cliffs, NJ.

1340

Variations in diagrams. There seems to be no domestic standard for diagrams. Some parts, including switches, show the insides of the part; others show only the outline, others just a block, others a symbol. Light bulbs can be seen as an outline, sometimes as a circle with the filament inside, other times as just the connector that hooks to the bulb or socket. Some diagrams do not show grounds (the service specialist has to assume the condition through the application of concepts). Fuses may be shown by the ~ symbol, an outline of a fuse, or sometimes just by the fuse holder. Connectors are shown in some diagrams but are not included in others. Student Supplement 1 will give you an idea of the various approaches used.

Many diagrams show all the wiring in a vehicle. Other diagrams come in sections; one diagram may show the circuitry for power windows and nothing else. If you are interested in the engine compartment, you will have to find that particular sectional diagram.

Reliability. Sometimes vehicle makers change their minds between the making of the diagrams and the wiring of the vehicle. What is really confusing is when the color codes do not match. There is nothing to do here but isolate the known wires and then, through logic, figure out what is left. It may be hard to ignore what the diagram is telling you, but sometimes that is all you can do. But, having a diagram is still better than having no diagram at all. For the most part, however, diagrams can be trusted.

PART A DIRECTIONS

Study the **Chrysler** wiring diagram printed on page 103 of this assignment sheet and then answer the following questions. Write the correct answers on the blanks provided.

1. What is the name of the device labeled **A** on the wiring diagram?

   Device A _____

2. What is the color and size of the wire used in circuit S4 at the automatic transmission neutral start switch?

   Wire size and color _____

3. How many connectors are used from the clutch start switch to the starter relay?

   Number of connectors _____

4. Circuit S2 is used to activate what device?

   Device activated _____

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5. If the dark-green wire in circuit S4 were open, which of the following would be the result?

   Result _____

   _____

   a. The starter would not crank
   b. The vehicle would start without applying the clutch
   c. The vehicle would crank but would not start
   d. The ignition switch would be damaged

6. Circuit S2 (the 18-gauge yellow wire) is used to activate which of the following components?

   Component activated _____

   a. Clutch start switch
   b. Starter relay
   c. Ignition relay
   d. Ignition switch

7. Which of the following circuits activates the starter solenoid?

   Circuit number _____

   a. J3
   b. S4
   c. S5
   d. DS5

PART B DIRECTIONS

Study the **Ford** wiring diagram printed on page 105 of this assignment sheet and then answer the following questions. Write the correct answers on the blanks provided.

1. What is the device labeled A in the seat-belt section of the wiring diagram?

   Device A _____

2. What is the function of circuit 139?

   Function _____

3. What is the purpose of circuit 57?

   Purpose _____

4. How many switch contacts are located in the ignition switch?

   Number of switch contacts _____

5. If circuit 640 was open, which of the following would be the result?

   Result _____

   _____

   a. The seat-belt buzzer would work, but the ignition-key warning buzzer would not
   b. Only the seat-belt buzzer would not work
   c. The seat-belt warning lamp would glow
   d. The seat-belt switch would complete the circuit

6. What would be the result if circuit 159 (red wire with a pink stripe) were shorted to ground?

   Result _____

   _____

   a. The ignition-key warning buzzer would not work
   b. There would be a blown fuse in the fuse box
   c. There would be a loss of power to circuit 158
   d. All of the above

7. If circuit 450 were open, what would be the result?

   Result _____

   _____

   a. The seat-belt buzzer would not work
   b. The seat-belt warning light would not work
   c. Both a and b
   d. Neither a nor b

PART C DIRECTIONS

Study the **General Motors** wiring diagram printed on page 107 of this assignment sheet and then answer the following questions. Write the correct answers on the blanks provided.

1. What is the name of the device labeled **A** on the wiring diagram?

   Device A _____

1343

2. What is the name of the device labeled **B** in the starting system?

   Device B _____

3. What color is the wire used in circuit 39?

   Wire color _____

4. The purple wire in circuit 6 is used to activate which of the following components?

   Component activated _____

   a. The starter solenoid
   b. The transaxle selector switch
   c. The clutch switch
   d. All of the above

5. Which of the following would be the result if the C100 connector in circuit 5 were unplugged?

   Result _____

   a. The engine would not run
   b. The vehicle would crank in any gear
   c. The starter would not crank
   d. None of the above

6. Which of the following components is protected by fusible link C?

   Component protected _____

   a. The alternator diodes
   b. The starter solenoid
   c. The ignition switch
   d. The regulator

PART D
DIRECTIONS

Study pages 109 through 111 of this assignment sheet. In this part of the assignment sheet, you will use the incomplete drawings and the information on those pages to complete a wiring diagram for a particular vehicle. Even though an automotive specialist does not usually do this kind of work—a design person does—drawing a wiring diagram yourself is perhaps the best exercise you can do to help you understand how to read and work with wiring diagrams.

To help you complete this exercise, your instructor will provide you with the following information about the vehicle you will be drawing the diagram for.

1. The engine type
2. The distributor rotation
3. The firing order
4. Number 1 on the distributor
5. The types of side markers
6. The type of courtesy lights

Then your instructor will provide you with the following information for drawing the diagram.

1. The color codes
2. The fuse assignments
3. Whether or not grounds are to be shown
4. Whether or not to include fuse ratings
5. Whether or not to include connectors
6. Whether or not to include wire sizes

In completing this exercise, your drawing must conform to the following.

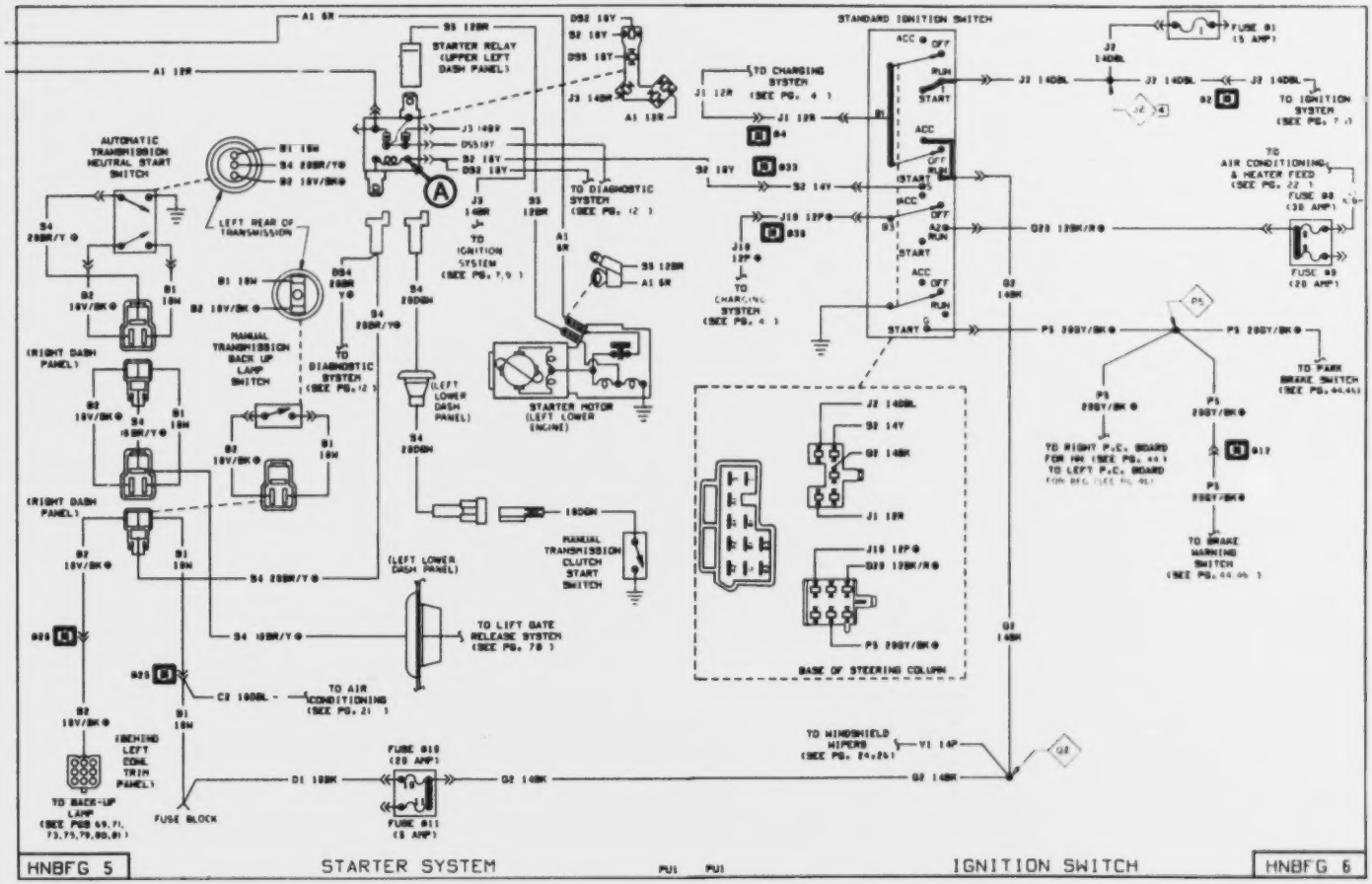
1. Use a straightedge; all the lines must be straight.
2. All lines must be vertical or horizontal.
3. The lines must be drawn in different colors.
4. Do not draw lines across units.
5. Select the shortest route.
6. Indicate splices by a dot on the connection.
7. No splices are to form a cross ("Ts" are okay).
8. Lines must be at least 1/16 inch from each other.

1345

Do not think that you will be able to do this assignment on the first try. Photocopy pages 109 and 111 and tape them together. Work with a plain pencil in your first attempt. Starting from the battery and working outward, draw one circuit at a time. Avoid leaving a line unfinished thinking that you will catch it later. It is too easy to forget.

1346

Used with permission of Chrysler Motor Corporation.


STARTER SYSTEM
IGNITION SWITCH
HNBFG 5
HNBFG 6
STANDARD IGNITION SWITCH
STARTER RELAY (UPPER LEFT DASH PANEL)
AUTOMATIC TRANSMISSION NEUTRAL START SWITCH
LEFT REAR OF TRANSMISSION
MANUAL TRANSMISSION BACK UP LAMP SWITCH
TO DIAGNOSTIC SYSTEM (SEE PG. 12)
TO IGNITION SYSTEM (SEE PG. 7,9)
STARTER MOTOR (LEFT LOWER ENGINE)
(LEFT LOWER DASH PANEL)
MANUAL TRANSMISSION CLUTCH START SWITCH
TO CHARGING SYSTEM (SEE PG. 4)
TO LIFT GATE RELEASE SYSTEM (SEE PG. 78)
TO AIR CONDITIONING (SEE PG. 21)
BASE OF STEERING COLUMN
TO WINDSHIELD WIPERS (SEE PG. 24,26)
TO AIR CONDITIONING & HEATER FEED (SEE PG. 22)
TO PARK BRAKE SWITCH (SEE PG. 44,45)
TO BRAKE WARNING SWITCH (SEE PG. 44,45)
TO RIGHT P.C. BOARD FOR HN (SEE PG. 40)
TO LEFT P.C. BOARD FOR BRC (SEE PG. 40)
(BEHIND LEFT SIDE TRIM PANEL)
TO BACK-UP LAMP (SEE PGS 69,71, 73,75,79,80,81)
FUSE BLOCK
FUSE 810 (20 AMP)
FUSE 811 (5 AMP)
FUSE 81 (15 AMP)
FUSE 88 (30 AMP)
FUSE 89 (20 AMP)

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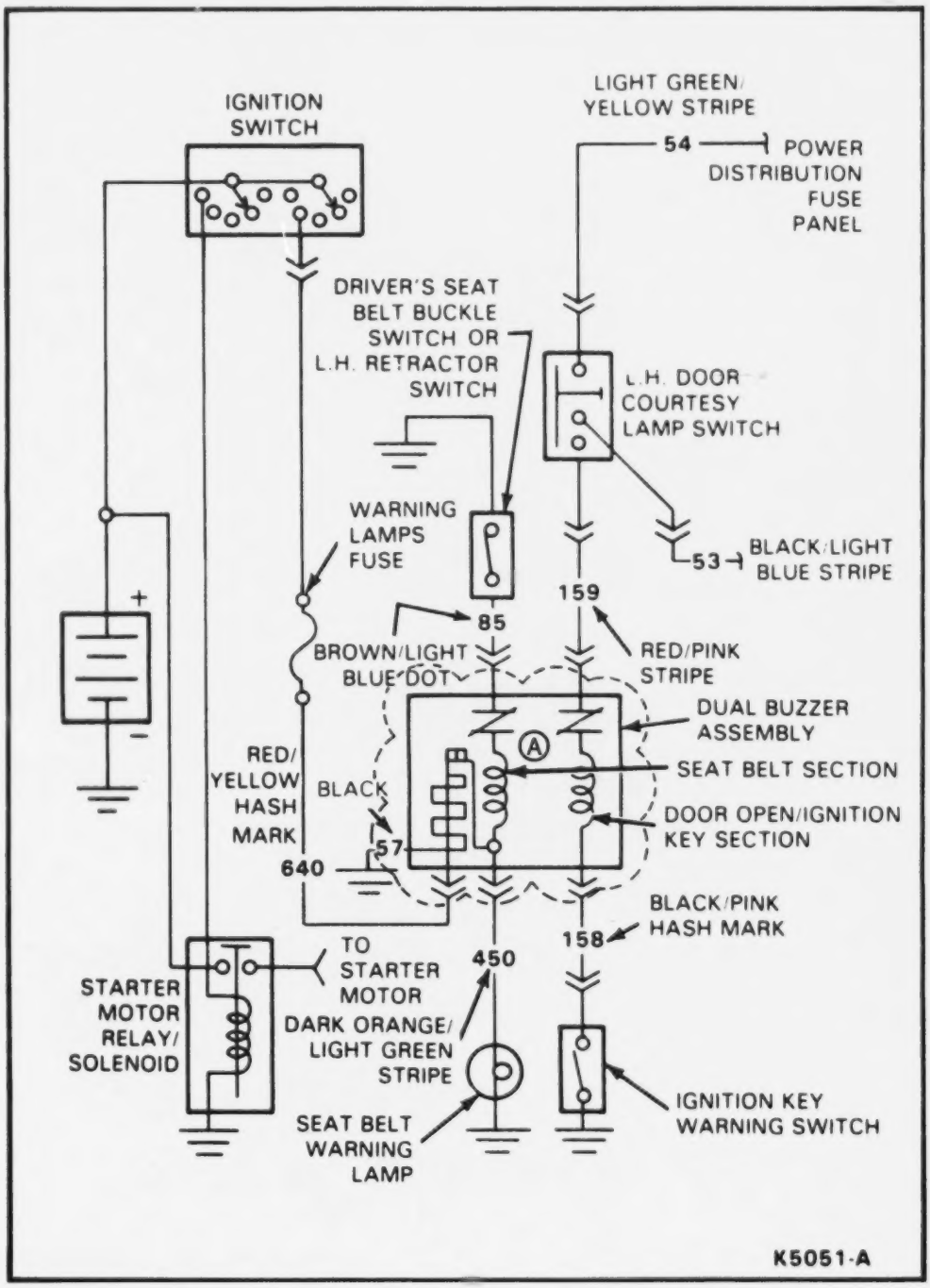
1348



Used with permission of Ford Motor Company.

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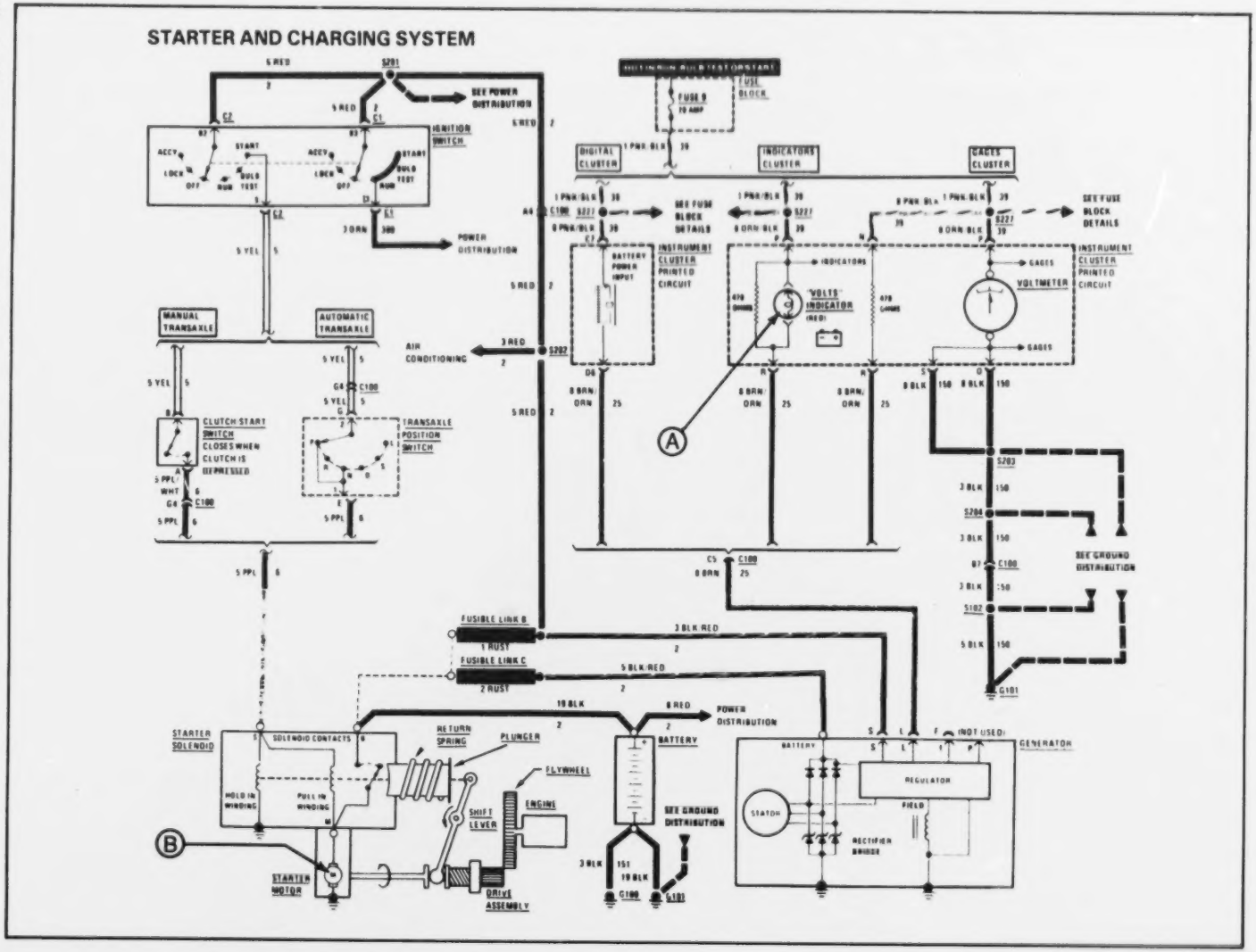
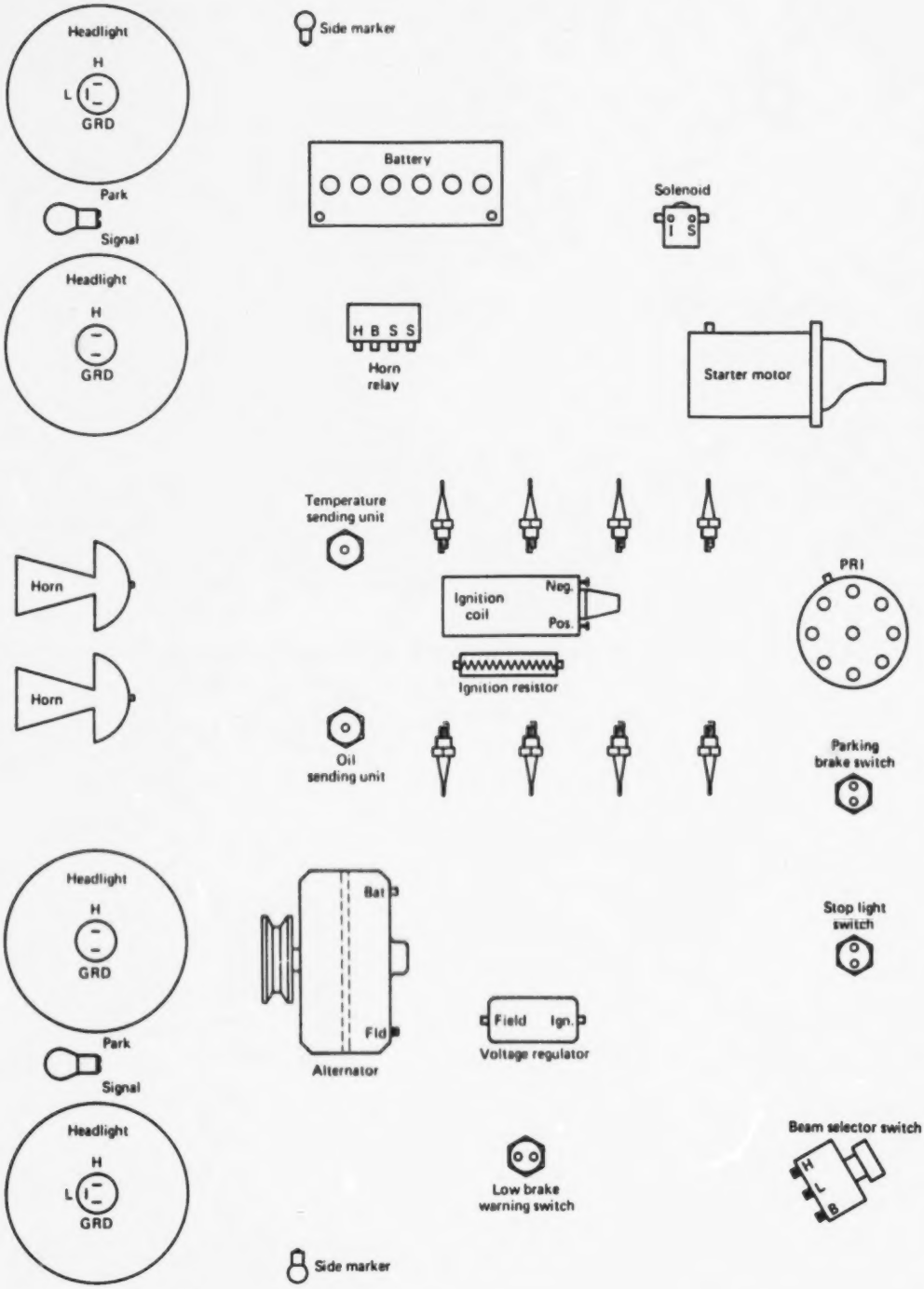
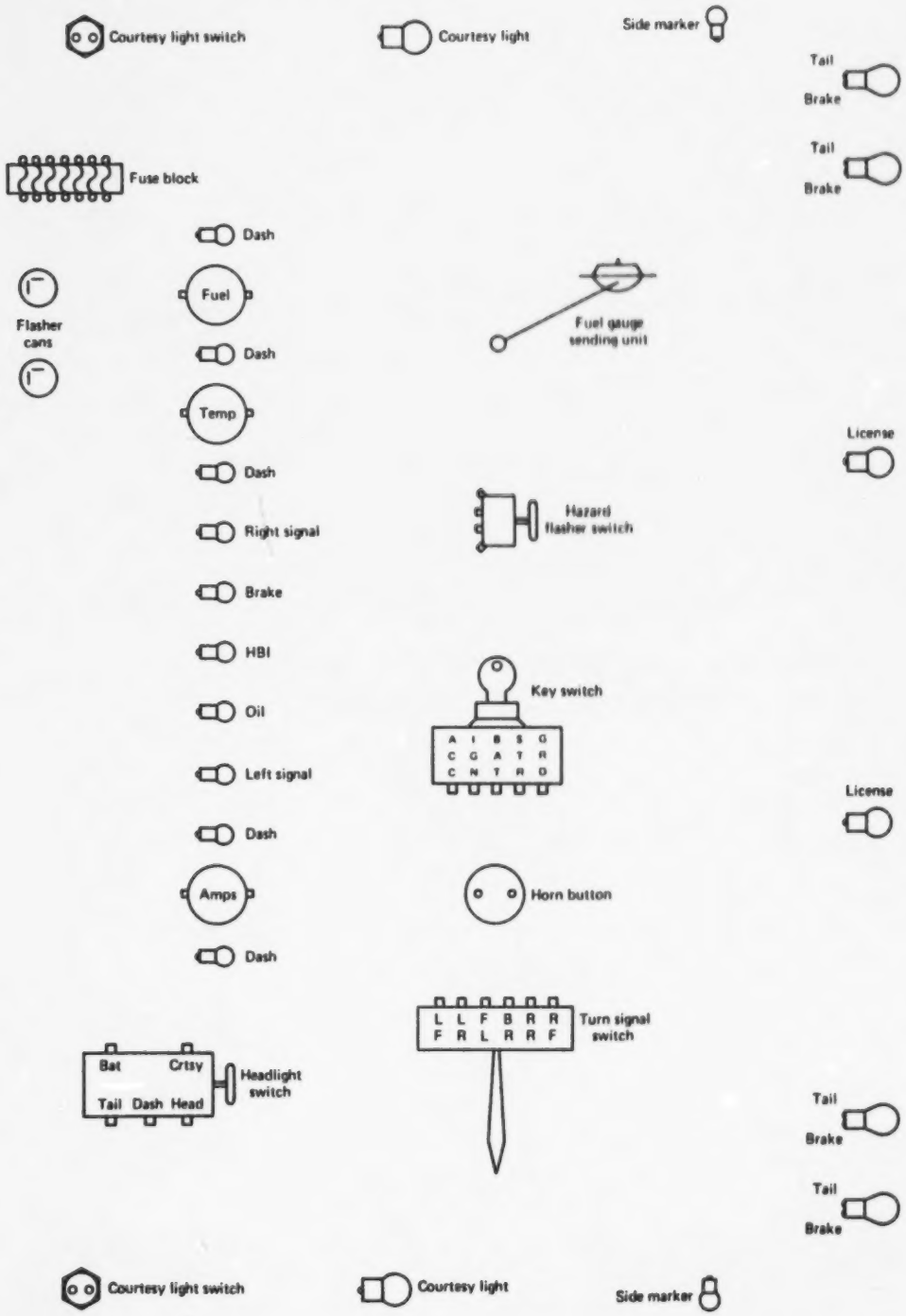
Used with permission of General Motors Corporation.




Headlight
H
L
GRD
Park
Signal
Headlight
H
GRD
Headlight
H
GRD
Park
Signal
Headlight
H
L
GRD
Side marker
Battery
Solenoid
I S
H B S S
Horn relay
Starter motor
Temperature sending unit
Horn
Horn
Ignition coil
Neg.
Pos.
Ignition resistor
PRI
Oil sending unit
Parking brake switch
Bat
Fld
Alternator
Field Ign.
Voltage regulator
Stop light switch
Low brake warning switch
Beam selector switch
H
L
B
Side marker

1352


Courtesy light switch
Courtesy light
Side marker
Tail
Brake
Tail
Brake
Fuse block
Dash
Fuel
Dash
Temp
Dash
Right signal
Brake
HBI
Oil
Left signal
Dash
Amps
Dash
Flasher cans
Fuel gauge sending unit
License
Hazard flasher switch
Key switch
A I B S G
C G A T R
C N T R O
License
Horn button
L L F B R R
F R L R R F
Turn signal switch
Bat
Crtsy
Tail Dash Head
Headlight switch
Tail
Brake
Tail
Brake
Courtesy light switch
Courtesy light
Side marker

ASSIGNMENT ANSWERS

APPLY RELATED ELECTRICAL PRINCIPLES

ASSIGNMENT SHEET 1

1. 46,900 ohms
2. 9 volts positive
3. 4.6 volts positive
4. 1.530 volts negative
5. 9.06 volts positive
6. 1.530 volts positive
7. 4,690 ohms
8. 2.45 amps
9. 1,000 ohms
10. 100 ohms
11. 100.6 ohms
12. 2.46 amps

ASSIGNMENT SHEET 2

PART A

1. Relay
2. 20-gauge wire, brown with yellow stripe
3. Two
4. The windings in the starter relay
5. The starter would not crank
6. Starter relay
7. S5

PART B

1. Relay
2. Warning circuit for the left-hand (driver's) door
3. Ground
4. Five
5. Only the seat-belt buzzer would not work
6. All of the above
7. The seat-belt warning light would not work

PART C

1. Bulb
2. Starter motor
3. Pink with black tracer
4. The starter solenoid
5. The starter would not crank
6. The alternator diode

PART D

Evaluated by the instructor

1354

JOB SHEET 1

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 13

Solder-splice electrical wiring

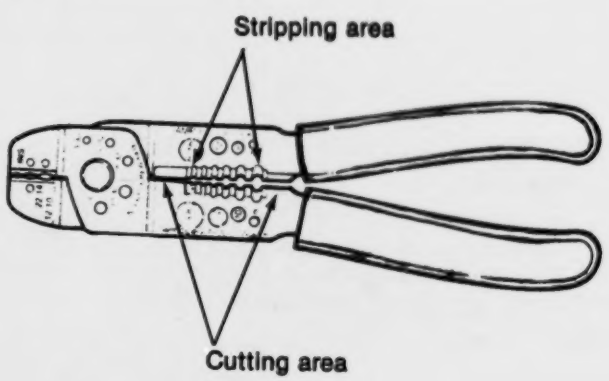
INTRODUCTION

Solder-splicing the conductors in an electrical circuit is a basic technique the automotive service technician must be able to use in order to repair conductors. Skills involved in this technique include stripping and cleaning the insulation from the conductors, preparing the soldering iron or gun for use, splicing the conductors by twisting the exposed wiring together, soldering the spliced wiring, and reinsulating the solder-spliced connection. Two requirements must be met when this type of repair is made to electrical conductors: (1) a good physical connection must be made so that the repaired conductor will resist the strain and vibration it will be subjected to in service and (2) a good electrical connection must be made to eliminate any reduction in the current-carrying capacity of the conductor as a result of the repair.

Stripping wire and cleaning exposed wiring

The recommended method of **stripping** a wire—or removing its insulation—is to use a wire-stripping-and-crimping tool (see Figure 1). In the stripping area of this tool are holes sized to match all common electrical-wire gauges. Using the proper hole for the gauge of the wire you are working with allows removal of the insulation without cutting, nicking, or damaging the wiring to be exposed. Cut, nicked, or damaged wiring reduces the current-carrying capacity of the conductor, and therefore, would prevent a good electrical connection. See Figure 2.

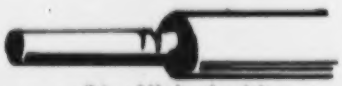
FIGURE 1



1355

FIGURE 2

(a) Cut wiring



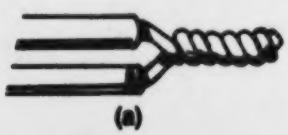
(b) Nicked wiring

After the insulation has been stripped back, the exposed wiring should be cleaned. Wiring to be soldered must be clean to create a good electrical connection. All traces of dirt, corrosion, oxidation, and oil or grease must be removed. Small-gauge wire (16-gauge or smaller) should be cleaned with a cleaning-flux solution that is squirted on the wiring or that the wiring is dipped into. Larger-gauge wire may be cleaned by careful scraping with a razor blade. When wiring is scraped, take care not to cut or nick the wiring, which would also reduce the current-carrying capacity of the conductor.

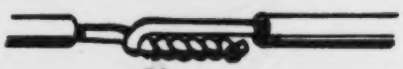
Solder-splicing exposed wiring

When the exposed wiring has been properly stripped and cleaned, several methods can be used to twist, or **splice**, the exposed wiring. Whichever method is used, the wires must be held together securely so that the conductors to be soldered will maintain a good physical connection. Some of the methods used to twist the exposed wiring are shown in Figure 3. Whichever method is used, the exposed wiring must be twisted gently. If stranded wiring is involved, the wiring must be twisted in the direction of the strand twist so that the strands do not separate, which would reduce the current-carrying capacity of the wiring.

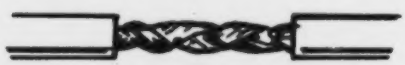
FIGURE 3



(a)



(b)



(c) Twist in direction of strand twist

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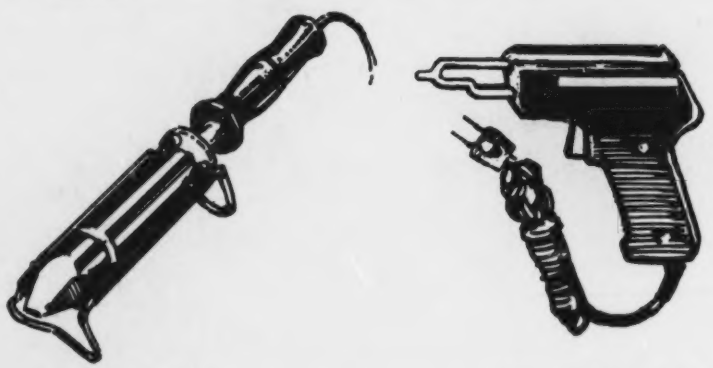
Soldering is a process used to bond the exposed pieces of spliced wiring to reform a good electrical connection. A soldering gun or iron is used as a heat source to heat the exposed wiring, melt the solder (an alloy of tin and lead), and cause the molten solder to flow between the heated pieces of wiring. Then, when the solder cools and hardens, the electrical connection is reformed.

The soldering iron or gun selected for a particular soldering job should be large enough to supply enough heat for the job, but not so large that it will heat the exposed wiring enough to melt the insulation up the wire from the splice. As a general rule, the larger and heavier soldering iron (see Figure 4 [a]) should be used when the wires to be soldered are large and require more heat to form a good electrical connection. However, the soldering gun with its smaller tip (see Figure 4 [b]) is used for many automotive electrical jobs because it provides enough heat for most applications and is lighter and easier to work with in tight areas.

FIGURE 4



(a) Soldering iron (b) Soldering gun

Rosin-core solder is usually used for soldering electrical wiring. The rosin core will not corrode the wiring as would the acid-base solder popular in other types of soldering. Acid-base solder should never be used in electrical circuits.

On light wiring 16-gauge or smaller or when the solder must be applied near electronic circuits, *certanium*, or solder designed for electronic circuitry, should be used. This type of solder melts at very low temperatures and prevents overheating of wiring and related circuitry. However, this type of solder should never be used outside of low-voltage or -amperage circuits.

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Before beginning the actual soldering process, the soldering iron or gun must be prepared for use. This involves cleaning and possibly reshaping the gun or iron tip and tinning the tip with a thin coat of rosin-core solder.

While preparing the soldering iron or gun for use and whenever you are working with solder during the soldering process, you should follow one important guideline.

- Always wear eye protection while soldering. Hot solder can cause serious eye injury.

Other guidelines to follow while soldering include

- Hold the tip of the soldering iron or gun so that a large area of the tip contacts the wiring to the soldered, and hold the solder on the wiring until the wiring itself gets hot enough to melt the solder. Enough heat must be generated so that the solder flows freely as a liquid and does not become pasty or mushy.

- Move the solder along the wiring to allow the solder to cover the length of the splice.

- Use only enough solder to flow between the wiring strands to form a good bond. Do not build up solder on the surface of the wiring.

- A well-soldered connection (joint) will appear smooth and shiny, with no apparent holes. A poorly soldered connection—a connection soldered with heat insufficient to properly heat the wire, called a *cold joint*—will have a dull, rough appearance.

- After the soldering process is complete, do not move the soldered wires until the solder has cooled and hardened. Moving the wires before the solder cools may break the solder bond.

- Test the solder-spliced connection by attempting to pull the connection apart by hand. If the connection seems loose, reheat the wire to melt the solder into the wires more thoroughly. Add more solder only if absolutely necessary.

Insulating solder-spliced connections

The final step in making a good solder-spliced connection is reinsulating the connection to prevent the exposed wiring from making an unwanted electrical connection and to protect the solder-spliced connection from moisture.

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The specialist may use one of two methods to form the tight covering required to reinsulate the connection: (1) electrical tape may be stretched and wrapped so that at least two layers cover the connection, or (2) heat-shrink tubing may be placed over the connection and then heated, causing it to shrink and cover the connection. Heat-shrink tubing is used in most applications today because it is more durable, and it should always be used on any connection that will be exposed to moisture.

EQUIPMENT AND MATERIALS

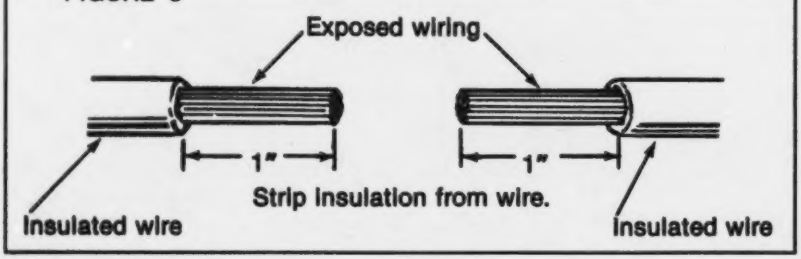
- Automotive manufacturer's reference manual
- Eye protection
- Wire-stripping-and-crimping tool
- Razor blade or cleaning-flux solution
- Soldering iron or gun
- Rosin-core solder
- Clean screwdriver
- Tinning oil or flux (soldering paste or liquid)
- Wet sponge
- Electrical tape or heat-shrink insulation and heat gun

PROCEDURE

For stripping wire and cleaning exposed wiring

1. Determine wire gauge
2. Test-strip insulation
   a. Using correct gauge hole in stripping area of wire-stripping-and-crimping tool, strip back insulation 3/8 inch from end of a wire
   b. Check exposed wiring for cuts or nicks
   c. *If* cuts or nicks occur, recheck for proper wire gauge and test again until insulation is removed without damaging exposed wiring
3. Strip 1 inch of insulation from end of each wire to be solder-spliced (Figure 5)

FIGURE 5



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4. Clean exposed wiring on small-gauge wire (16-gauge or smaller) with cleaning-flux solution; clean large-gauge wire by carefully scraping with a razor blade

CAUTION

Take care **not** to cut or nick the wiring.

PROCEDURE

For preparing soldering-iron or -gun tip for use

1. Put on eye protection
2. When soldering iron or gun is cool before connecting its power cord to power receptacle, inspect tip for proper wedge shape
3. *If* tip is **not** properly wedge-shaped, check with your instructor to determine proper shaping procedure, and shape tip, removing as little metal as possible

   NOTE: Most tips can be shaped with file; however, irons or guns with iron-clad tips should **not** need reshaping. Normally, iron-clad tips are merely cleaned with a wire brush. Filing will shorten their useful life. Gold-plated tips are very expensive and should **never** be filed.

4. Place soldering iron or gun in holder, connect power cord to power receptacle, and allow iron or gun to heat
5. When iron or gun is hot, use tip of clean screwdriver to place a drop of tinning oil or flux (soldering paste or liquid) onto each tip surface
6. Place wet sponge on work surface
7. Holding iron or gun over wet sponge, apply rosin-core solder to each tip surface; wipe excess solder from tip onto wet sponge

CAUTION

Keep iron or gun over sponge on work surface. Hot solder dripping from the soldering iron or gun can burn your skin or damage your clothing.

8. Disconnect power cord from power receptacle, place iron or gun in holder, and allow to cool
9. Have instructor inspect soldering tip

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PROCEDURE

For solder-splicing wiring

1. *If* using heat-shrink insulation, cut and slide insulation onto one conductor

   NOTE: Slide tubing back far enough on the conductor to keep it from being heated during the soldering process.

2. Form spliced connection by gently twisting exposed wiring ends together; *if* stranded wire is involved, twist in direction of strand twist so that strands do **not** separate

3. Plug soldering-iron or -gun power cord into power receptacle and allow to heat

4. When iron or gun is hot, heat exposed wiring and apply solder to spliced connection just until solder flows freely among all exposed wiring strands

   CAUTION

   Do **not** build up solder on spliced connection. The solder-spliced connection will break if too much solder is applied. Do **not** move the solder-spliced wires until the solder has hardened and cooled. Moving the wires before the solder cools may break the connection.

5. Test cooled and hardened solder-spliced connection by attempting to pull connection apart by hand

6. *If* connection seems loose, reheat wire to melt solder into the wires more thoroughly and retest when solder cools

7. Have instructor inspect cooled and hardened solder-spliced connection

8. When solder-spliced connection is secure, reinsulate connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation

   NOTE: Use a heat gun to apply heat to heat-shrink insulation. Do **not** use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

9. Have instructor inspect insulated connection

10. Remove eye protection

11. Clean work area and return equipment and materials to proper storage

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JOB SHEET 2

APPLY RELATED ELECTRICAL PRINCIPLES

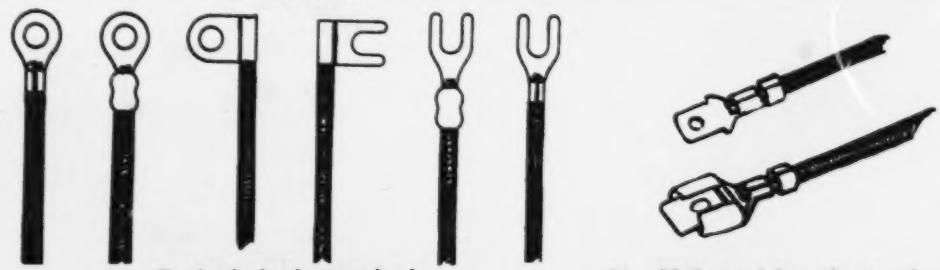
OBJECTIVE 14

Install terminals and connectors

INTRODUCTION

A *terminal* is a small conductive metal device that is attached to the end of a wire so that the wire may be easily connected and disconnected to other wires or electrical-circuit components. Some terminals are designed to be used singly and some are designed to be used in attaching pairs. When two terminals attach, one terminal is called a *female terminal* and the other is called a *male terminal*. See Figure 1.

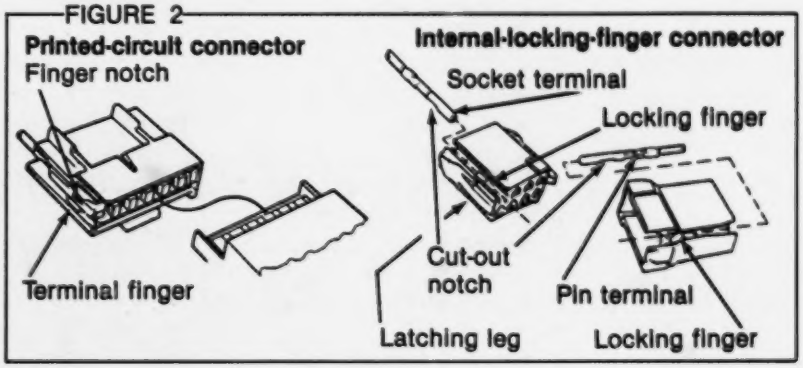
FIGURE 1



(a) Typical single terminals (b) Male and female terminals

A *connector* is a nonconductive plastic device that holds two or more terminals in position. Connectors provide a way of disconnecting components or a portion of a circuit from the main wiring harness. Connectors are also designed in attaching pairs, with one connector holding male terminals and the other holding female terminals, or with each having a mixture of male and female terminals. See Figure 2.

FIGURE 2



Used with permission of Ford Motor Company.

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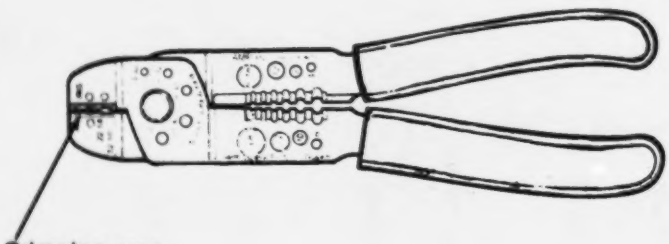
As for solder-spliced wires, two requirements must be met when terminals and connectors are installed: (1) a good physical connection and (2) a good electrical connection must be made. To meet both of these requirements, terminals and connectors to be used in locations exposed to moisture or in circuits carrying large amounts of current must be soldered in place. For most other applications, terminals and connectors can merely be crimped to wires with the crimping area of a wire-stripping-and-crimping tool (see Figure 3). This type of installation is called *solderless* and is made with solderless terminals and connectors.

FIGURE 3



Solderless terminals and connectors are color-coded to ensure that you select the proper terminal or connector for the conductor to which it will be attached.

- Solderless terminals and connectors with **red** ends are to be used with **18-gauge and smaller** conductors.
- Those with **blue** ends are to be used with **14- and 16-gauge** conductors.
- Those with **yellow** ends are to be used with **10- and 12-gauge** conductors.

EQUIPMENT AND MATERIALS

- Automotive manufacturer's reference manual
- Terminals and connectors
- Eye protection
- Wire-stripping-and-crimping tool
- Razor blade or cleaning-flux solution
- Soldering iron or gun
- Rosin-core solder
- Clean screwdriver
- Wet sponge
- Electrical tape or heat-shrink insulation and heat gun

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PROCEDURE

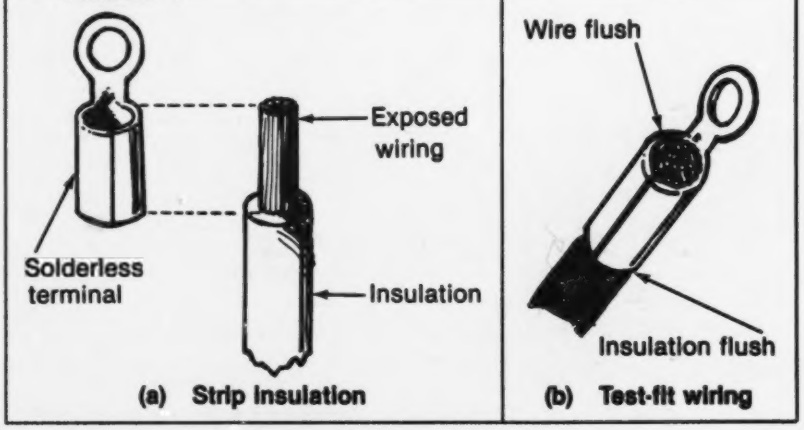
For installing a solderless conductor or terminal

1. Determine wire gauge
2. Select connector or terminal to match wire gauge
3. Test-strip insulation from wiring until insulation is removed without damaging exposed wiring (see Job Sheet 1)

   NOTE: Cut or nicked wiring will reduce the current-carrying capacity of the wiring.

4. Strip insulation from end of wire to expose enough wiring to permit installation of connector or terminal (see Figure 4 [a])

FIGURE 4



(a) Strip insulation (b) Test-fit wiring

5. Test-fit wiring in terminal or connector

   NOTE: The insulation on the wire should be cut so that it will butt squarely against the terminal or connector and be stripped to a length so that the exposed wiring will enter the terminal or connector completely. See Figure 4 (b). If the insulation does not butt squarely, it should be recut, and if too much insulation has been removed, the wiring should be trimmed.

6. *If* necessary, correct cut and trim wire
7. Clean exposed wiring on small-gauge wire (16-gauge or smaller) with cleaning-flux solution; clean larger-gauge wiring by carefully scraping with razor blade

   CAUTION

   Take care **not** to cut or nick the wiring.

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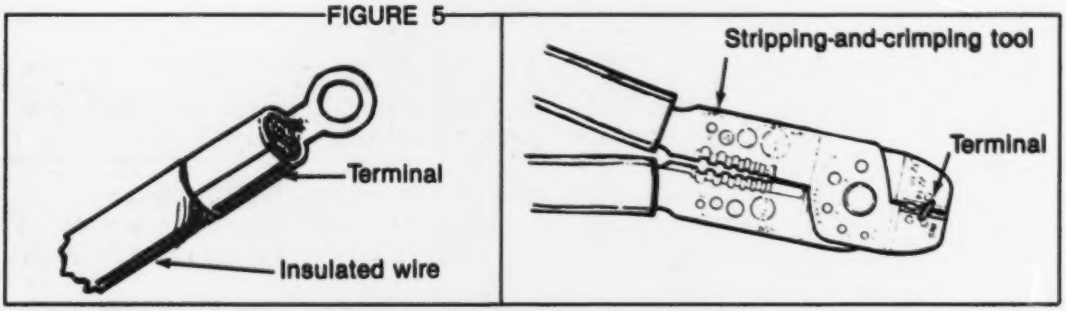
8. *If* using heat-shrink insulation, cut and slide insulation onto conductor

9. Clean terminal or connector with sandpaper

10. Place exposed wiring into terminal or connector, and form crimped connection using crimping area of wire-stripping-and-crimping tool (Figure 5)

FIGURE 5



11. Test crimped connection by pulling on the wire

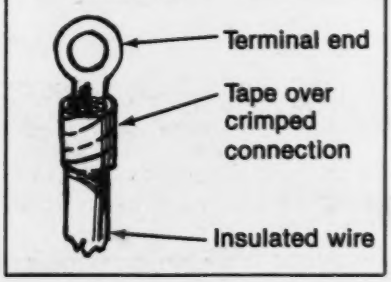
    NOTE: You should **not** be able to pull the wire out of a good crimped connection.

12. *If* crimped connection is secure, have instructor check connection

13. Insulate crimped connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation (Figure 6)

    NOTE: Use a heat gun to apply heat to heat-shrink insulation. Do **not** use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

FIGURE 6



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PROCEDURE

For installing a soldered terminal or connector

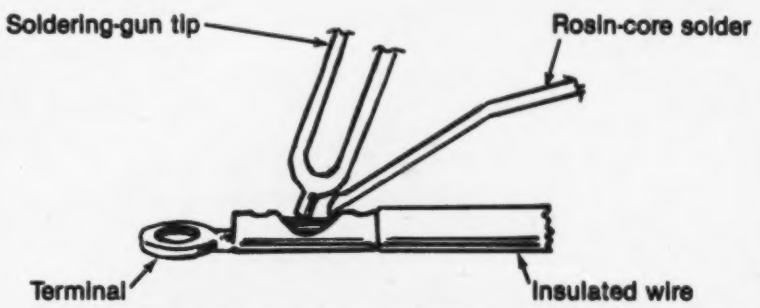
1. Follow steps 1 through 12 for installing a solderless terminal or connector
2. Prepare soldering-iron or -gun tip for use (see Job Sheet 1)
3. Plug soldering-iron or -gun power cord into power receptacle and allow to heat
4. *If* using heat-shrink insulation, cut and slide insulation onto conductor

   NOTE: Slide tubing back far enough on the conductor to keep it from heating during the soldering process.
5. When iron or gun is hot, heat exposed wiring and apply rosin-core solder to crimped connection, applying only enough solder to attach terminal or connector securely (see Figure 7)

   CAUTION

   Do not build up solder on crimped connection. The connection will break if too much solder is applied. Do not move the connection until the solder has hardened and cooled. Moving the connection before the solder cools may break the connection.

FIGURE 7

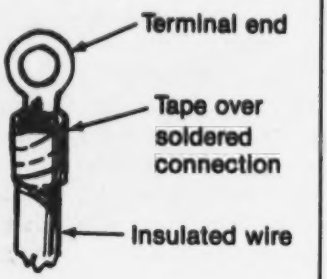


6. Test cooled and hardened connection by attempting to pull connection apart by hand
7. *If* connection seems loose, reheat wire to melt solder more thoroughly and retest when solder cools
8. When connection is secure, have instructor inspect cooled and hardened soldered connection

9. Insulate soldered connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation (Figure 8)

   NOTE: Use a heat gun to apply heat to heat-shrink insulation. Do **not** use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

FIGURE 8



10. Have instructor inspect insulated connection

11. Remove eye protection

12. Clean work area and return equipment and materials to proper storage

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JOB SHEET 3	APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 15

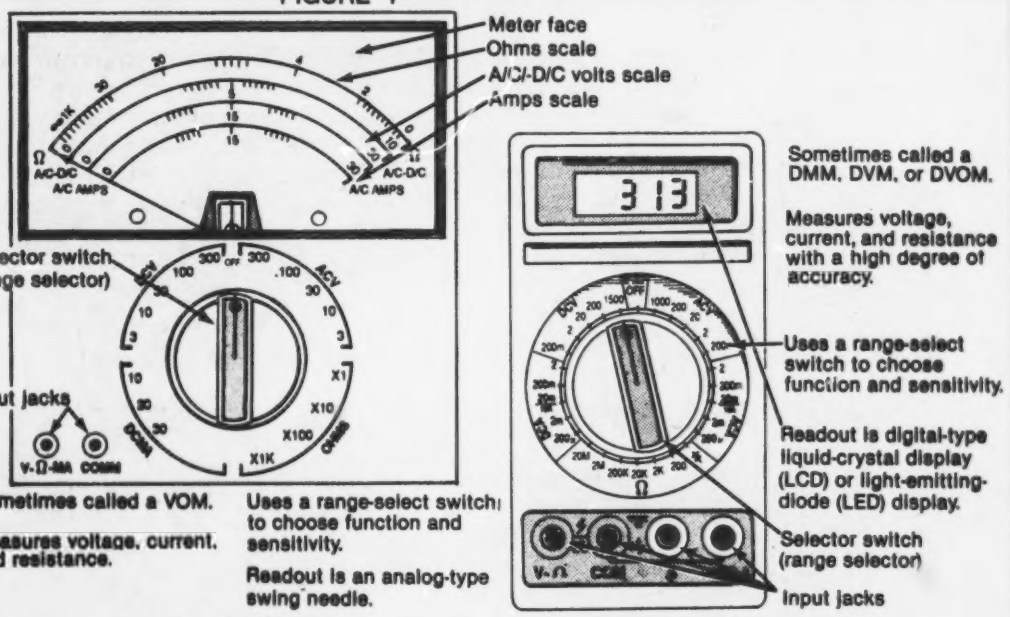
Measure current, voltage, and resistance with a multimeter

INTRODUCTION

To measure current, voltage, or resistance in an automotive circuit, the specialist may use individual pieces of test equipment—an ammeter to measure the amount of current (amps), an ohmmeter to measure the amount of resistance (ohms), or a voltmeter to measure the amount of pressure (volts). Or, the technician may choose to use a multimeter, a test instrument that combines these three individual meters in one case with a function knob that can be turned to select the type of measurement to be made.

There are two types of multimeters: analog and digital. While analog multimeters (meters that have a pointer or needle that moves across a numbered dial or scale) are available (see Figure 1 [a]), today most automotive specialists use electronic meters that provide a digital readout as shown in Figure 1 (b).

FIGURE 1


Meter face
Ohms scale
A/C-D/C volts scale
Amps scale
Selector switch (range selector)
Input jacks
Sometimes called a VOM.
Measures voltage, current, and resistance.
Uses a range-select switch to choose function and sensitivity.
Readout is an analog-type swing needle.
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Sometimes called a DMM, DVM, or DVOM.
Measures voltage, current, and resistance with a high degree of accuracy.
Uses a range-select switch to choose function and sensitivity.
Readout is digital-type liquid-crystal display (LCD) or light-emitting-diode (LED) display.
Selector switch (range selector)
Input jacks

(a) Analog meter (b) Digital meter

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A digital multimeter must be used when testing computer inputs and outputs and most electronic circuits where voltage test results must be precise. The readouts are direct-reading on an LED (light-emitting diode) display or LCD (liquid-crystal) display. The digital meter is available in two different models: switchable range-selector or autoranging. The autoranging version automatically selects the proper range of the test or circuit under test.

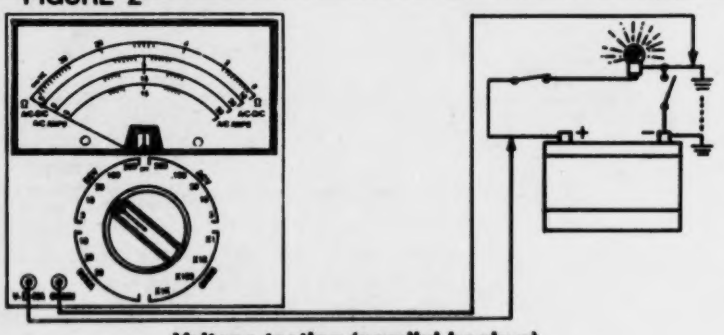
Use of the analog multimeter is limited to testing circuits where current draw through the system is not critical or to tuning of some circuits that require monitoring of the voltages that change with adjustments made during alignment procedures. These slow changes are easier to see on the rising and falling pointer-type display of an analog meter than they are to interpret in the changing digits of a digital-meter display. An analog meter is never used to test computer circuits and is not used to test most circuits with electronic components.

However, although there are several types of multimeters with various types of displays, a multimeter is still basically three separate meters performing separate functions, and you must connect the meter differently and take different precautions when using each meter function.

Voltmeter function

To use a multimeter's voltmeter function, the instrument is normally connected into the test circuit in parallel, with the multimeter probes placed in the test circuit on either side of the load being tested, as shown in Figure 2. Before attempting to use the voltmeter function of a multimeter, you must determine the correct voltage range and set the meter for that range. Once obtained, the voltmeter reading can be compared to specifications to determine whether an electrical problem exists.

FIGURE 2



Voltage testing (parallel hookup)

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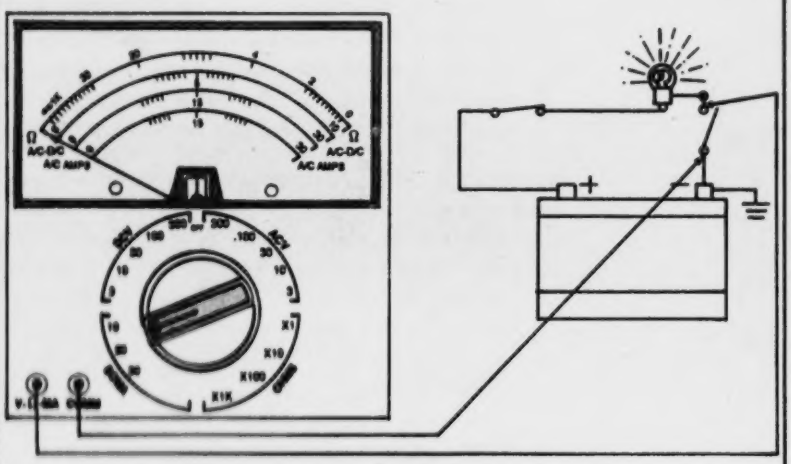
Ammeter function

Since the ammeter function of a multimeter measures the amount of current flowing in a circuit under test, current must flow through the instrument. For current to flow through the instrument, the meter must be connected in series in the circuit. See Figure 3. This means the meter's probes must be placed in the test circuit between the power source and the load so that all the current going to the load goes first through the meter.

FIGURE 3



Amp testing (series hookup)

When working with the ammeter function, you must take care never to connect a multimeter in parallel to the circuit under test. If a multimeter in the ammeter function is connected in parallel, the multimeter may be destroyed.

Ohmmeter function

When used as an ohmmeter, a multimeter measures the amount of resistance in a circuit or circuit component. It can be used to measure the resistance of a load, a control, a safety device, and the wire that connects those circuit components. When switched to the ohmmeter function, the multimeter has its own built-in power source. To prevent damage, the multimeter in the ohmmeter function must never be connected to a source of voltage. The part or wire to be tested should be disconnected from the circuit. See Figure 4.

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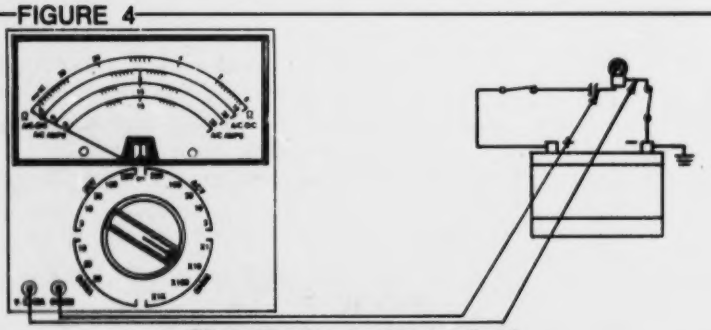
FIGURE 4



Ohms testing (series hookup)

Most meters in the ohmmeter function have a small adjustable resistor that allows you to adjust, or "zero" the meter before each use. This adjustment provides compensation for the gradual discharge of the small battery contained in the meter.

The resistance of certain electrical-system parts is specified in service manuals, and the ohmmeter function of the meter often provides the only means to determine if those parts are serviceable. In addition to measuring the resistance of parts, most automotive specialists use the ohmmeter function to check continuity and to check for unwanted resistance in controls, wires, and connections.

CAUTION

Whenever you use a multimeter in any function, handle it with great care. It is a delicate instrument and can be damaged by being dropped or knocked about when used in the shop or taken into the field for service jobs.

EQUIPMENT AND MATERIALS

- Multimeter
- Multimeter manufacturer's instruction manual
- Automotive circuit
- Automotive manufacturer's reference manual

PROCEDURE

For measuring circuit current (amps)

1. Check service manual for wiring diagram of circuit under test to determine
   - Range of circuit under test

     NOTE: This information is **not** always given on the wiring diagram.
   - Procedure for opening circuit under test
   - Best test location for circuit under test (where to attach meter in circuit)

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2. Check meter manufacturer's instruction manual to determine

   - Proper meter scale for measuring amps (analog meter)
   - Proper meter setting for measuring amps in circuit under test

     NOTE: Most hand-held meters are capable of measurements in the 10-amp range. You may have to obtain a special shunted meter, such as a VAT-40, for certain automotive circuits.

   - Procedure for plugging test probes into meter for measuring amps

3. Open circuit under test as directed in service manual (step 1)

4. Plug test probes into meter as directed in meter manufacturer's instruction manual (step 2)

5. *If* service manual wiring diagram lists range of circuit under test, set meter range-selector switch to correct position for circuit under test

6. *If* service manual wiring diagram does **not** list range of circuit under test (you are working with unknown currents), set meter range-selector switch on highest setting

   CAUTION

   Setting the meter on too low a setting could damage the meter.

7. Attach test probes in **series** at circuit test location determined in step 1

8. *If* using an analog meter, check to be sure you are using proper meter scale for amps reading

9. *If* you are unable to get a meter reading, position range-selector switch at progressively lower settings until reading is achieved

10. *If* meter reads backwards, reverse probes and take another reading

    NOTE: *If* an analog meter is reading backwards, the needle will swing to the left. *If* a digital meter is reading backwards, the display will show a negative reading.

11. Record reading when obtained

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12. Report reading to your instructor

PROCEDURE

For measuring circuit voltage (volts)

1. Check service manual for wiring diagram of circuit under test to determine

   - Range of circuit under test

     NOTE: This information is **not** always given on the wiring diagram.

   - Procedure for opening circuit under test
   - Best test location for circuit under test

2. Check meter manufacturer's instruction manual to determine

   - Proper meter scale for measuring volts (analog meter)
   - Proper meter setting for measuring volts in circuit under test
   - Procedure for plugging test probes into meter for measuring volts

3. Open circuit under test as directed in service manual (step 1)
4. Plug test probes into meter as directed in meter manufacturer's instruction manual (step 2)
5. *If* service manual wiring diagram lists range of circuit under test, set meter range-selector switch to correct position for circuit under test
6. *If* service manual wiring diagram **does not** list range of circuit under test, set meter range-selector switch at a position slightly greater than 12 volts

   NOTE: Since most automotive electrical systems operate on 12 volts, setting the switch at a setting slightly higher than 12 volts will protect the meter from damage.

7. Attach test probes in **parallel** at circuit test location determined in step 1
8. *If* using an analog meter, check to be sure you are using proper meter scale for volts reading

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9. *If* you are unable to get a meter reading, position range-selector switch at progressively lower settings until reading is achieved

10. *If* meter reads backwards, reverse probes and take another reading

    NOTE: *If* an analog meter is reading backwards, the needle will swing to the left. *If* a digital meter is reading backwards, the display will show a negative reading.

11. Record reading when obtained

12. Report reading to your instructor

PROCEDURE

For measuring circuit resistance (ohms)

1. Check service manual for wiring diagram of circuit under test to determine

   - Range of circuit under test

     NOTE: This information is **not** always listed on the wiring diagram.

   - Power source for circuit under test
   - Procedure for opening circuit under test
   - Best test location for circuit under test

2. Check meter manufacturer's instruction manual to determine

   - Procedure for zeroing meter for ohms reading
   - Proper meter scale for measuring ohms (analog meter)
   - Procedure for plugging test probes into meter for measuring ohms
   - Proper meter setting for measuring ohms in circuit under test

3. Zero meter following manufacturer's instructions (step 2)

   NOTE: You must make a zero-ohms adjustment each time you move the range-selector switch to a new resistance position.

4. *If* meter is at zero-ohms reading, continue testing procedure

5. *If* meter is **not** at zero-ohms reading, follow manufacturer's instructions for adjusting meter to zero reading

6. Turn off power to circuit under test (step 1)

   CAUTION

   When working with an ohmmeter, the power must be off in the circuit under test. Damage to the meter will result if the power to the circuit is **not** off.

7. Open circuit under test (step 1)

8. Plug test probes into meter as directed in manufacturer's instruction manual (step 2)

9. *If* service manual wiring diagram lists range of circuit under test, set range-selector switch to the correct position for circuit

10. *If* service manual wiring diagram does **not** list range of circuit under test, set meter range-selector on lowest setting

11. Attach test probes in **parallel** at circuit test location determined in step 1

12. *If* using an analog meter, check to be sure you are using proper meter scale for ohms reading

13. *If* you are unable to get a meter reading, position range-selector switch at progressively higher settings until reading is achieved

14. Record reading when obtained

15. Report reading to your instructor

16. Clean work area and return equipment and materials to proper storage

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JOB SHEET 4	APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 16

Test and replace miniature light bulbs and test their sockets

INTRODUCTION

In the days of less complex automotive electrical circuitry, testing and replacing miniature light bulbs and their light sockets was a relatively simple task performed day to day by the service specialist. However, with the invention of the electronic components now commonly found in the circuitry of such systems as the taillight, turn-signal, license-plate light, and parking-light systems, testing and replacing the bulbs and sockets in these circuits has become more complicated. The specialist must now be able to read the service manual procedures and the wiring diagrams for these lighting systems to recognize the properties of the various circuits involved before he or she knows which test equipment can be safely used on the various lighting circuits, how to troubleshoot the various components of the system, or even how to get to a burned-out bulb and which bulb should be used to replace one that has burned out in the system.

Exposing exterior lights

Before you can test and replace a bulb, you must be able to get at the bulb, or *expose* it. This may be more difficult than it may first appear. On most vehicles, the designs of the parking lights, taillights, and side-marker lights change with every vehicle style change, and each style change often requires a change in the procedure for exposing a bulb. The exact procedure for exposing a bulb for a particular vehicle must be found in the vehicle-manufacturer's service manual. But once you determine just how you can get to a particular bulb, exposure is usually achieved in one of two ways:

1. You remove the lens that covers the bulbs (see Figure 1), or
2. You remove a pull-out socket-and-bulb assembly from a portion of the vehicle, such as from inside the trunk, behind the bumper, inside the fender, or from under the hood (see Figure 2).

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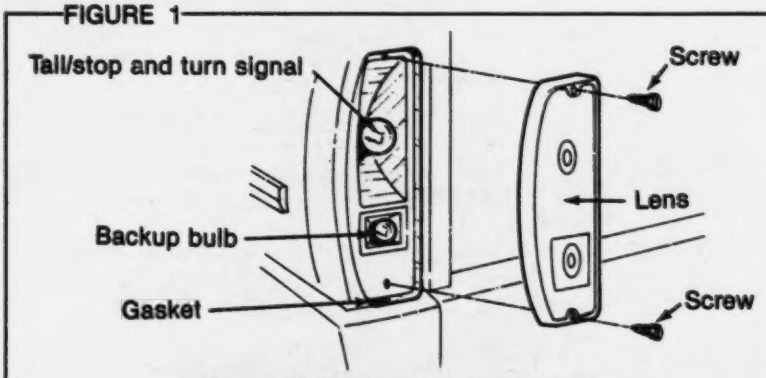
FIGURE 1



Removing the lens to replace bulb

FIGURE 2

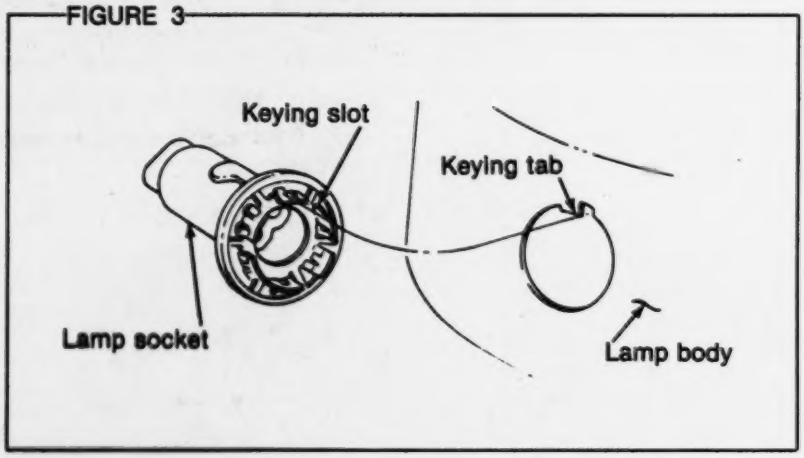
Figures 1 and 2 used with permission of State of Florida, Department of State.

Lens removal. Most lenses covering exterior lights and some lenses covering interior lights are held in place by screws located on the edge of the lens or frame. Removing those screws allows you to remove the lens and expose the bulb. When removing the lens screws, you must hold the lens firmly and remove the lens very carefully so that you do not break the lens or tear the gasket that is often located between the lens and its mounting.

Lenses for many interior lights are usually of the type that snap into place and are removed by squeezing the lens or by prying it loose from its mounting. When removing this type of lens, you must also hold the lens firmly and remove the lens carefully so that you do not break the lens. Once removed, you should inspect the lens to see that it does not have any cracks or other defects. If there is a gasket with the lens, also inspect it for cracks. Replace the lens and gasket if defective.

Pull-out socket-and-bulb-assembly removal. Pull-out socket-and-bulb assemblies usually have locating-keys or -tabs on the socket that align with slots on the vehicle's body. This tab-and-slot arrangement locks the socket assembly in place and allows removal and installation of the assembly only in one position (see Figure 3). To remove the bulb-and-socket assembly from the vehicle, you must push in the socket assembly and turn it counterclockwise so that the keys or tabs are aligned properly with the slots for removal.

FIGURE 3



Used with permission of Ford Motor Company.

Inspecting and testing the bulb

In many instances, you can visually check a bulb and determine that it is burned out or otherwise defective. If the filament of a single-filament bulb (or either filament of a double-filament bulb) is broken or missing, or if the glass portion of the bulb is loose from its base, the bulb is defective and should be replaced. However, sometimes a bulb that "looks good" isn't, and considering how difficult bulbs can be to expose, even a bulb that looks good should be tested to make sure before it is reinstalled.

Testing the light socket

If inspecting and testing the bulb determine that the bulb is not defective but the bulb still does not light, you must test the light socket. However, before and during the test, you must take certain precautions. First, you must check the wiring diagram to determine whether or not there are electronic components in the circuit. If there are, you must use an LED-type test light rather than a bulb-type test light, which could blow the electronic components in the circuit. Also, locate the circuit's power source and remove power from the circuit except during the actual testing of the circuit.

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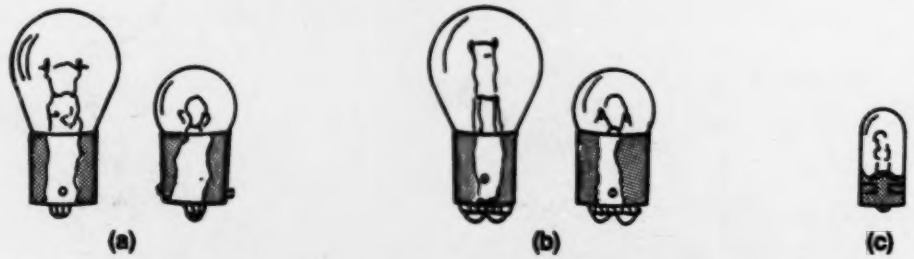
Replacing the bulb

Most exterior light bulbs—those found in the taillights, backup lights, license-plate lights, and parking lights—are small ball-shaped single-filament glass bulbs with a single-contact metal base. The metal base usually has index lugs that are used to line up and secure the bulb in position in its socket (see Figure 4 [a]). However, many other types of bulbs are used throughout a vehicle. In the brake lights, turn signals, and parking lights, there are double-filament, double-contact bulbs (see Figure 4 [b]), and wedge-shaped bulbs with no metal base—called *wedge bulbs*—are found friction-fitted in plastic or rubber sockets in side-marker lights and instrument-panel lights (see Figure 4 [c]).

FIGURE 4



These various bulbs are identified by a numbering system used by most automobile manufacturers. The wiring diagrams for the vehicle will identify each bulb with its reference number. Therefore, when replacing a light bulb, it is not enough to find a bulb that looks like the original and fits in the same socket, you must check the wiring diagram and find the bulb reference number to obtain an exact duplicate of the original bulb. If not, the bulb you put in the circuit may not function properly in that circuit or it may draw more current than the circuit was designed for.

Installing lenses and socket-and-bulb assemblies

When installing a lens with screws and a gasket, make sure you keep the gasket in its proper place between the lens and the mounting. The gasket prevents dirt and moisture from entering the light housing and proper placement is essential. Also you must make certain you hold the lens securely in place, but do not overtighten the screws, which could crack or break the lens.

To install a socket-and-bulb assembly, you must align the locating-tabs or -keys with the slots on the vehicle frame, push in the assembly, and then turn it clockwise to relock it in place.

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EQUIPMENT AND MATERIALS

- Automotive lighting circuit
- Automotive service manual and wiring diagram
- Light-bulb pliers
- Appropriate screwdriver
- Socket-cleaning brush

PROCEDURE

For exposing and inspection bulb

1. Make sure switch that operates bulb is turned off

   CAUTION

   The switch must be turned off to prevent a short while you expose the bulb and clean the light socket.

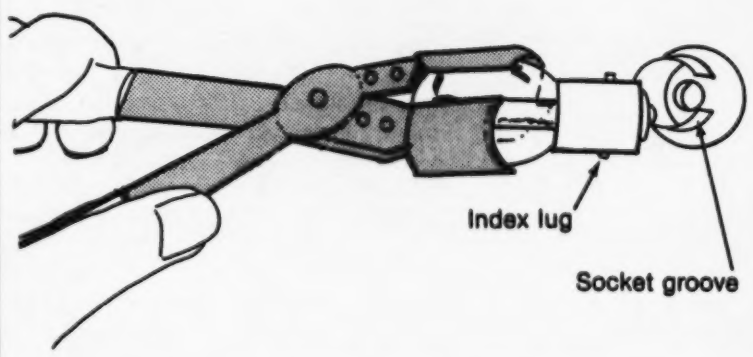
2. Expose bulb for inspection: Check service manual to determine proper method of exposing bulb for removal from its socket

3. Remove exposed bulb from socket: Using light-bulb pliers, turn bulb about 1/4 turn to unlock index lugs from socket groove, then pull bulb straight out of socket (Figure 5)

   CAUTION

   Do **not** use your fingers to remove a bulb from its socket. Use light-bulb pliers to protect your fingers from broken glass should the bulb break during removal.

FIGURE 5



Adapted with permission of the State of Florida, Department of State.

4. Inspect bulb

   - For signs of corrosion on bulb base (see Figure 6); and *If* base is corroded, clean with sandpaper

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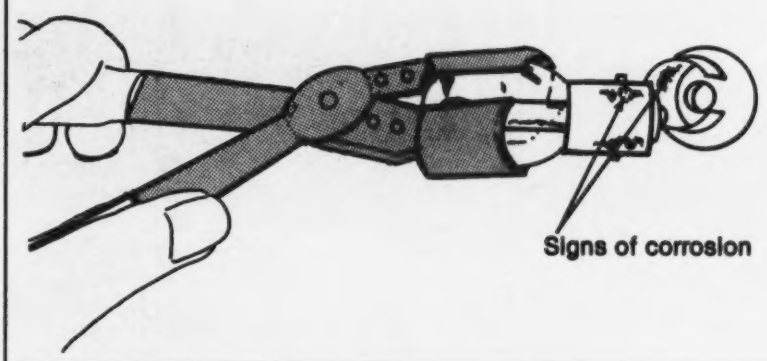
- For signs that glass is loose from bulb base, and *if* so, check service manual and obtain proper replacement bulb

5. *If* original bulb does **not** appear defective, test light bulb with ohmmeter or ohmmeter function of multimeter (see Job Sheet 3)

6. *If* original bulb tests defective, check service manual for proper replacement bulb and obtain

7. Inspect socket housing for signs of corrosion (Figure 6), and clean socket with socket-cleaning brush *if* necessary

FIGURE 6



Used with permission of the State of Florida, Department of State.

8. Insert replacement bulb or original bulb into light socket, making sure bulb index lugs fit into socket grooves properly

   NOTE: *If* the index lugs are offset, one groove in the socket will be deeper than the other. This lets you know you have installed the wrong bulb.

9. Turn on switch that operates bulb to test that bulb will now light

10. *If* bulb does light, turn off switch to light and restore bulb and socket to proper condition

11. *If* bulb does **not** light, test socket to determine whether or not current is getting to socket

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PROCEDURE

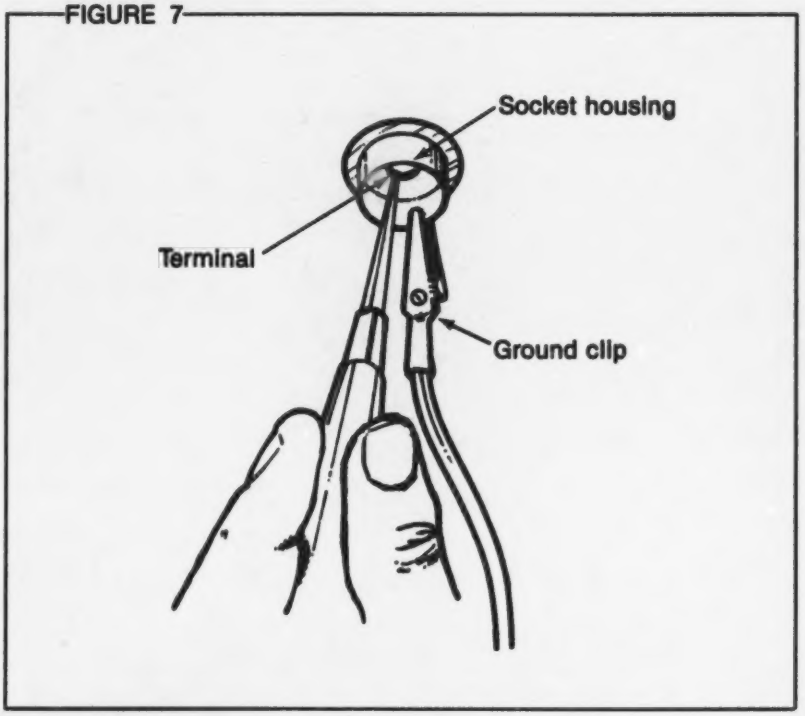
For testing single-terminal light socket (backup lights, side-marker lights)

1. Remove bulb from socket
2. Clip ground clip of 12-volt test light to socket housing or other good ground (see Figure 7)
3. Touch sharp point of test-light probe to light-socket terminal (Figure 7)

CAUTION

Do **not** allow test-light probe to contact socket housing; this could cause a short that would blow fuses in the circuit.

FIGURE 7



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4. Record test results: *If* test light does **not** light up, electrical current is **not** present at socket; *if* test light does light up, electrical current is present at socket
5. Notify instructor of test results
6. Install bulb and socket in vehicle: Check service manual for proper method of installing bulb and socket

7. Clean work area and return equipment and materials to proper storage

PROCEDURE

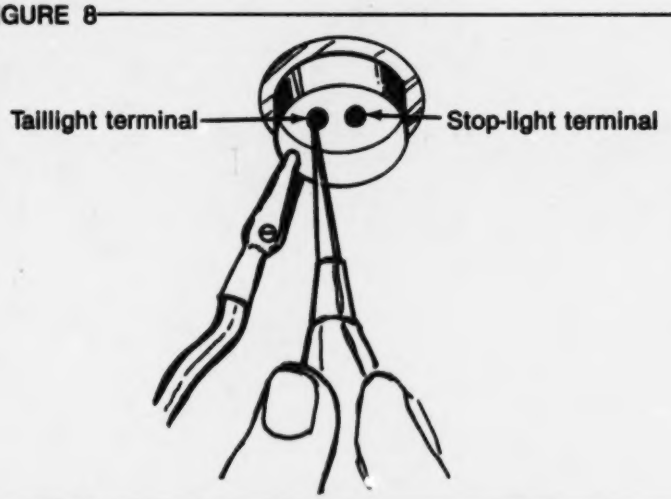
For testing dual-terminal light socket (stop lights, taillights, front parking lights, turn-signal lights)

1. Remove bulb from socket
2. Clip ground clip of 12-volt test light to socket housing or other good ground (see Figure 8)
3. Check vehicle wiring diagram to determine which terminal should be tested
4. Touch sharp point of test-light probe to correct light-socket terminal (Figure 8)

CAUTION

Do **not** allow test-light probe to contact socket housing; this could cause a short that would blow fuses.

FIGURE 8



5. Record test results: *If* test light does **not** light up, electrical current is **not** present at socket; *If* test light does light up, electrical current is present at socket
6. Notify instructor of test results
7. Install bulb and socket in vehicle: Check service manual to determine proper method of installing bulb and socket
8. Clean work area and return equipment and materials to proper storage

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JOB SHEET 5

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 19

Perform state-of-charge test on a conventional battery

INTRODUCTION

In Objective 17 of the Information Sheet, you learned a basic principle of battery operation: A battery contains acid, and the acid level in the battery is affected during charging, discharging, and recharging. By expanding slightly on this basic principle, you can understand the more complex principles affecting conventional-battery state-of-charge testing.

The acid in a battery is called *electrolyte*. Electrolyte is a mixture of sulfuric acid dissolved in water. This mixture of water and acid weighs more than plain water because sulfuric acid is heavier than water.

When a battery is fully charged, the sulfuric-acid content of the electrolyte in the battery is at its maximum, and consequently, the weight of the electrolyte is at its maximum. When a battery discharges, the sulfuric acid dissolved in the electrolyte moves from the electrolyte into the cell plates. As the acid leaves the electrolyte, the weight of the electrolyte decreases. Therefore, the weight of the electrolyte can be used as an indicator of the battery's state of charge:

- When the weight of the electrolyte is low, the battery's state of charge is low.
- When the weight of the electrolyte is high, the battery's state of charge is high.

So, it would seem that to determine the approximate state of charge of a battery, you only need a scaled piece of equipment to measure the weight (called the *specific gravity*) of the electrolyte. The equipment used to measure specific gravity of electrolyte is called a *hydrometer*. However, to get an accurate reading from a hydrometer, one other principle must be considered:

- A change in temperature will change the specific gravity of electrolyte, which in turn affects the accuracy of the reading you will get from the hydrometer.

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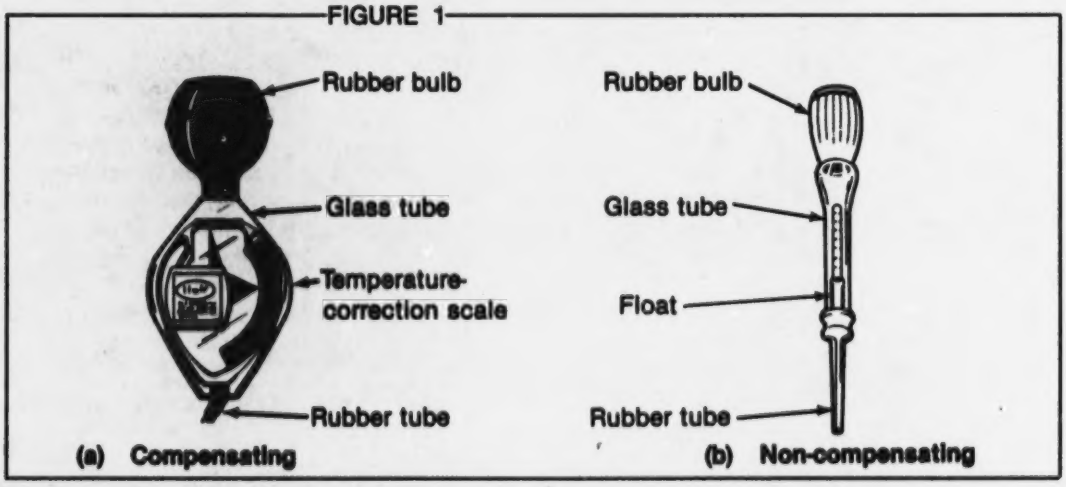
Eighty degrees F is the accepted electrolyte-temperature standard for specific-gravity readings. This means at an electrolyte temperature of 80 degrees, you can obtain an accurate specific-gravity rating. But at temperatures higher than 80 degrees, there will be a lose in the specific gravity of the electrolyte caused by the expansion of the liquid as its temperature rises. And at temperatures lower than 80 degrees, there will be a gain in the specific gravity of the electrolyte caused by the contraction of the liquid as its temperature falls. For this reason, the specific-gravity reading you obtain with a hydrometer is affected by electrolyte temperatures higher or lower than the standard, and this effect must be compensated for in order to obtain an accurate reading.

Two common types of hydrometers are used for measuring the specific gravity of the electrolyte in conventional batteries: temperature-compensating and non-temperature-compensating. See Figure 1.

FIGURE 1



Used with permission of the State of Florida, Department of State.

When using a non-temperature-compensating hydrometer, you must measure the temperature of the electrolyte and then perform a simple mathematical calculation to compensate for electrolyte temperatures above or below the 80-degree standard.

For every 10 degrees of electrolyte temperature above 80 degrees, four gravity points (.004) must be added to the hydrometer's specific-gravity reading. For example, if you obtain a reading of 1.234 at 120 degrees F, which is 40 degrees above the standard (80 degrees), four points must be added for every 10 degrees, a total addition of 16 gravity points (.016). The temperature-compensated reading would then be 1.250.

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For every 10 degrees of electrolyte temperature below 80 degrees, four gravity points must be subtracted from the hydrometer's specific-gravity reading. For example, if you obtain a specific-gravity reading of 1.282 at 0 degrees F, four points must be subtracted for every 10 degrees below the standard of 80 degrees. Therefore, a total deduction of 32 gravity points (.032) would be required, making a temperature-compensated reading of 1.250.

With temperature-compensating hydrometers, there is no need to make these calculations. They are designed with a floating ball-type device that expands and contracts with temperature changes and automatically gives a temperature-compensated reading.

Once you have obtained a temperature-compensated specific-gravity reading from each cell in the conventional battery, you can easily translate the reading into a battery state-of-charge percentage using a specific-gravity/state-of-charge conversion chart. Table 1 below is an example of a typical conversion chart.

TABLE 1: Specific-gravity/state-of-charge chart

% Charged	Dry Charge or Wet Process (1.265 Full Charge)	Spin Processed (1.250 Full Charge)	Tropical (1.225 Full Charge)	Arctic (1.290 Full Charge)
100	1.265	1.250	1.225	1.290
95	1.250	1.235	1.210	1.275
75	1.230	1.220	1.180	1.255
50	1.200	1.190	1.130	1.225
25	1.170	1.160	1.090	1.195
Discharged	1.140	1.130	1.045	1.165

Used with permission of Chrysler Corporation.

Use the chart to determine the normal charged reading for cells in the type of battery you are working with, and then compare each cell reading you recorded to the normal charged reading and all other cell readings.

The readings for all the cells must be within the range given for normally charged cells of each battery type, and the cell readings must all be within 0.050 points of each other. If the cell readings do not meet both of these requirements, you must charge the battery and then retest the battery's state of charge. If the cell readings still do not meet these requirements, you must replace the battery.

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EQUIPMENT AND MATERIALS

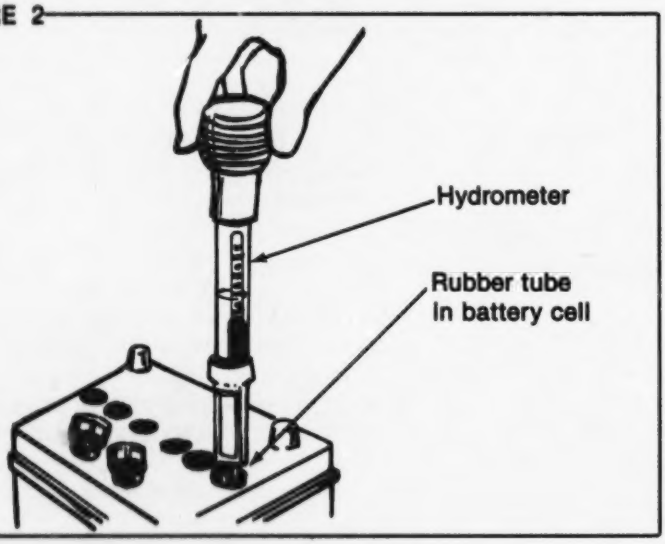
- Conventional battery
- Hydrometer
- Specific-gravity/state-of-charge chart
- Fender covers
- Shop towels and brush
- Water container
- Eye protection
- Rubber apron
- Rubber gloves
- Pencil and paper

PROCEDURE

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery to be tested is in vehicle, place fender covers over fenders
3. Perform visual inspection of battery; clean battery *if* necessary
4. Remove battery filler caps
5. Squeeze hydrometer bulb
6. Insert rubber hydrometer tube into electrolyte in filler hole over first battery cell (see Figure 2)
7. Slowly release rubber bulb to draw proper amount of electrolyte into hydrometer (Figure 2)

   NOTE: Do **not** lift hydrometer out of electrolyte.

FIGURE 2



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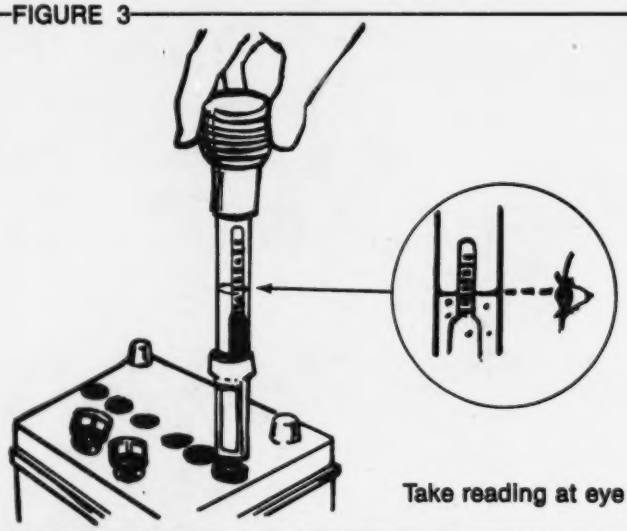
8. Check to be certain that hydrometer is clean and functioning properly: The float should be suspended in the electrolyte; it should **not** bump the top of the hydrometer tube or stick to the side

9. Holding the hydrometer level, bend down until you are at eye level with hydrometer scale; take reading (Figure 3)

FIGURE 3



Take reading at eye level.

10. Record reading

11. Squeeze bulb to return electrolyte to cell

12. Repeat steps 5 through 11 for each battery cell

13. Replace filler caps

14. *If* using a non-temperature-compensating hydrometer, adjust readings for temperature and record

15. Interpret test results

    a. Check specific-gravity chart to determine battery state-of-charge percentage

    b. *If* cell readings are all within range given for normally charged cells of battery type, and all are within 0.050 points of each other, record state-of-charge reading, clean battery, and return to service

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c. *If* cell readings do **not** meet both requirements in step b, record state of charge, slow-charge battery (Job Sheet 7), and then retest state of charge

d. *If* cell readings still do **not** meet requirements, replace battery

16. Report test results to instructor

17. Clean work area and return equipment and materials to proper storage

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JOB SHEET 6

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 20

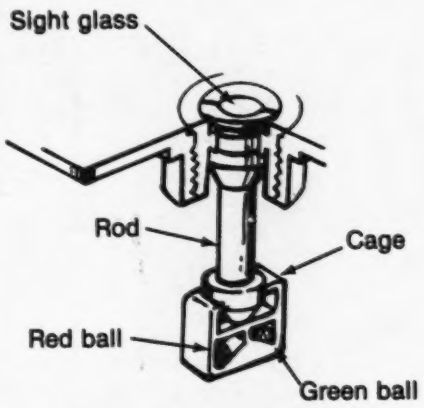
Perform state-of-charge check on a sealed battery

INTRODUCTION

The traditional state-of-charge test performed on conventional batteries cannot be performed on sealed batteries. Because a sealed battery never needs to have water added and, therefore, has no filler holes and filler caps in the battery case (see Figure 1 [a]), a traditional hydrometer cannot be inserted into the electrolyte in the battery cells.

FIGURE 1

(a) Sealed battery



(b) Hydrometer components

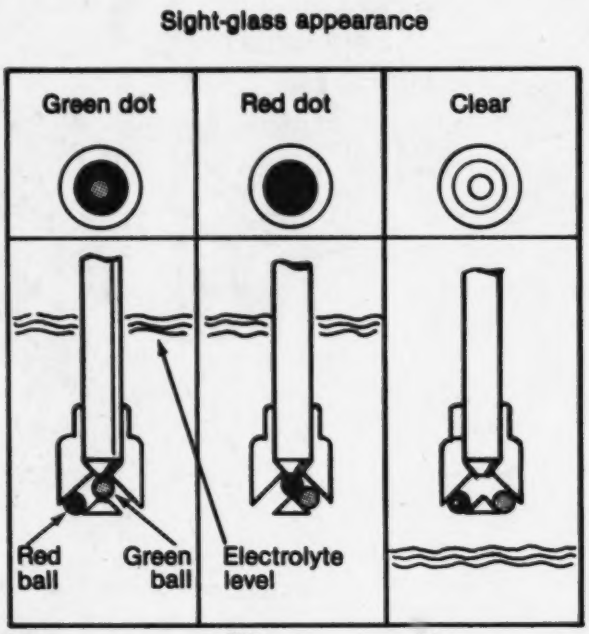
Sealed batteries are designed with a special hydrometer that is built into the battery case. This special type of hydrometer consists of a sight glass, a glass or plastic rod that extends down into the electrolyte, a cage that is attached to the lower end of the rod, and a red and green ball that float inside the cage. See Figure 1(b). As the battery's state of charge changes, the red and green balls move up and down inside the cage, and the state of charge is indicated by the changing appearance of the hydrometer's sight glass due to the rising and falling of the balls.

- When the green ball rises and touches the bottom of the rod, a green dot appears when you look down into the hydrometer's sight glass. See Figure 2 (a). The green dot indicates that the battery's state of charge is 65 percent or greater.

- When the battery's state of charge is below 65 percent, the green ball moves down in the electrolyte and rests at the bottom of the cage and the red ball rises and touches the bottom of the rod. The green dot disappears, and a red dot appears when you look down into the sight glass. See Figure 2 (b).

- If the battery's electrolyte level drops below the lower end of the hydrometer cage, both the red and green ball move down and rest at the bottom of the cage and the sight glass has a clear or light yellow appearance. A clear or light yellow sight glass indicates that the battery must be replaced. See Figure 2 (c).

FIGURE 2



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EQUIPMENT AND MATERIALS

- Sealed battery
- Fender covers
- Shop towels and brush
- Water container
- Eye protection
- Rubber apron
- Rubber gloves
- Flashlight
- Small screwdriver
- Pencil and paper

PROCEDURE

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is in vehicle, place fender covers over fenders
3. Perform visual inspection of battery; clean battery *if* necessary
4. Locate battery's built-in hydrometer
5. Look straight down into hydrometer, using flashlight beam *if* necessary in poorly lit area
6. Determine battery state of charge
   a. *If* green dot shows in hydrometer sight glass, battery state of charge is at 65 percent or above, and battery is charged enough for further testing
   b. *If* red dot shows in sight glass, battery is below 65 percent state of charge and must be slow-charged (Job Sheet 7) before further testing is performed
   c. *If* hydrometer appears clear or light yellow, electrolyte level may be low and battery may need to be replaced
   d. *If* clear or light yellow appearance is present, tap hydrometer lightly with a small screwdriver to dislodge any gas bubbles that may be giving a false indication of low electrolyte level; *if* clear or light yellow appearance remains, battery must be replaced
7. Record battery state of charge
8. Report results to instructor
9. Clean work area and return equipment and materials to proper storage

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JOB SHEET 7	APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 21

Slow-charge a battery

INTRODUCTION

Slow-charging a battery is the safest and most effective way to charge a battery, and, as such, is the recommended method used in battery service. To slow-charge a battery, you apply a charge figured in *ampere-hours*—the charge rate in amperes for a period of time in hours. For example, a 10-ampere charge rate for seven hours would be a 70-ampere-hour (AH) charge.

For most batteries, the battery charger used in this procedure (see Figure 1) is adjusted somewhere in the 3- to 10- or 15-ampere range—5 amperes being typical—and set for a time sufficient to bring the specific gravity of the electrolyte to its highest reading. However, the exact ampere-hour setting to use for a particular battery is difficult to determine because the following factors affect charging rates and times.

FIGURE 1

- **The battery's size or electrical capacity in ampere-hours.** (A completely discharged 70-AH battery requires almost twice the recharging time and rate as a completely discharged 40-AH battery.)
- **The temperature of the battery's electrolyte.** (It takes about two hours longer to charge a battery with an electrolyte temperature at 0 degrees F than at 80 degrees F.)
- **The battery's state of charge.** (A completely discharged battery requires twice as much charge as a battery that is half discharged.)
- **The battery's age and condition.** (A battery that has seen much service will require a higher rate of charge for a longer time than will a relatively new battery.)
- **The battery type.** (Sealed batteries usually require a longer, more constant rate of charge than a conventional battery. Some chargers will even have a switch indicating the type of battery to be charged.)

Though the exact rate and time to be used during the charge is difficult to determine, setting the charger at an exact time and rate is not as important in slow-charging as for other battery-service procedures because this procedure is performed at relatively low charge rates. In fact, in slow-charging it is safe to apply the following rules-of-thumb.

- Any battery may be charged at any rate above 3 amperes for as long as spewing of electrolyte due to violent gassing does not occur, and for as long as the battery's electrolyte temperature does not exceed 125 degrees F. If spewing of electrolyte occurs, or if electrolyte temperature exceeds 125 degrees F, the charging rate in amperes must be reduced or temporarily stopped to avoid damaging the battery.

- A conventional battery is considered fully charged when, after time- and charging-rate requirements have been met, all cells are gassing freely (but not spewing liquid electrolyte), specific gravity tests at between 1.260 and 1.280, and no change occurs in specific gravity readings when tested over a three-hour period after the charging procedure.

- A sealed battery is considered fully charged when, after time- and charging-rate requirements have been met, the green dot is visible in the hydrometer's sight glass.

One procedure that is important and must be followed exactly during the slow-charge is the sequence you use in connecting and disconnecting battery cables and charger leads. If you do not follow the correct sequence, a spark can result that can ignite battery gases and cause the battery to explode.

Other general battery-safety guidelines, including the following, must also be adhered to.

- Always wear safety glasses and protective clothing during the procedure.

- Do not allow electrolyte to contact any part of the vehicle, especially the vehicle's finish.

- Do not smoke during the procedure or do anything that would create sparks; the battery gases may ignite and cause the battery to explode.

- Never attempt to charge a frozen battery. A frozen battery may rupture or explode during the procedure.

1394

EQUIPMENT AND MATERIALS

- Battery and manufacturer's specifications
- Battery charger and manufacturer's operating instructions
- Appropriate service manual
- Fender covers
- Eye protection
- Rubber gloves
- Rubber apron
- Damp cloths or paper towels
- Thermometer
- Flashlight
- Pencil and paper

PROCEDURE

For slow-charging a conventional battery

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is in vehicle, place fender covers over fenders
3. *If* battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete
4. Check battery temperature
   a. Remove battery filler caps
   b. Look down into filler holes over battery cells, using flashlight beam *if* necessary in poorly lit area, and determine condition of battery electrolyte
   c. *If* electrolyte appears to be frozen or *if* ice crystals are visible in electrolyte, allow battery to thaw fully before continuing procedure
5. Cover battery filler holes with damp cloth or damp paper towel
6. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate and time for specific battery
7. Record charge rate and time
8. Prepare battery for charge
   a. *If* battery is in vehicle, disconnect battery cables from terminals

► WARNING ◄

Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

1395

(1) Disconnect grounded-terminal cable clamp

(2) Disconnect insulated-terminal cable clamp

b. *If* charging battery with side-mounted terminals, insert post adapters to provide a good connection for charger

9. Follow charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery-terminal posts or adapters

► WARNING ◄

Connecting charger leads to battery-terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

10. Turn on charger, adjust charging rate and time

11. Charge battery for 15 minutes

12. Check appearance of battery and test electrolyte temperature

a. Check battery filler holes for possible spewing of electrolyte

b. Insert thermometer into battery cell and take electrolyte-temperature reading

c. *If* electrolyte temperature exceeds 125 degrees F, and/or electrolyte spewing has occurred, reduce charging rate and continue to recheck every 15 minutes until charging rate is adjusted to meet requirements in step d

d. *If* electrolyte temperature is below 125 degrees F and there is no spewing of electrolyte, continue charging until allotted time has passed

13. After allotted charge time has passed, check battery filler holes for charged appearance: Battery should be gassing freely

14. Follow charger manufacturer's instructions for disconnecting charger from battery

► WARNING ◄

Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

1396

15. Perform three battery state-of-charge tests (Job Sheet 5) at intervals of one hour; record each reading

16. Interpret state-of-charge test results

    a. Full-charge specific-gravity reading should be within a range of from 1.260 to 1.280; *if* readings remain within this range and do **not** drop during testing period, clean battery and return to service

    b. *If* specific-gravity readings drop during testing period, battery must be replaced

17. Clean work area and return equipment and materials to proper storage

PROCEDURE

For slow-charging a sealed battery

1. Put on eye protection, rubber gloves, and rubber apron

2. *If* battery is in vehicle, place fender covers over fenders

3. *If* battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete

4. Check battery temperature

    a. Determine temperature of environment battery was exposed to during hours before testing

    b. *If* battery was exposed to subfreezing temperatures and battery appears frozen, allow battery to thaw fully before continuing procedure

5. Test battery state of charge

    a. Perform battery state-of-charge check (Job Sheet 6)

    b. Record state-of-charge check results

    c. *If* hydrometer appears clear or light yellow, do **not** proceed with slow-charging procedure; replace battery

    d. Proceed with slow-charge only *if* red dot appears in built-in hydrometer

6. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate and time for specific battery

1397

7. Record charge rate and time

8. Prepare battery for charge

   a. *If* battery is in vehicle, disconnect battery cables from terminals

      ► WARNING ◄

      Disconnecting the battery cables in any other than the following sequence can cause the battery to explode.

      (1) Disconnect grounded-terminal cable clamp

      (2) Disconnect insulated-terminal cable clamp

   b. *If* charging battery with side-mounted terminals, insert post adapters to provide a good connection for charger

9. Follow charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery-terminal posts or adapters

   ► WARNING ◄

   Connecting charger leads to battery terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

10. Turn on charger; adjust charging rate and time

11. Charge battery for 15 minutes

12. Check appearance of battery

    a. Check battery vent holes for possible spewing of electrolyte

    b. Put a light behind battery and look through plastic battery case to check for bubbling of electrolyte

    c. *If* electrolyte spewing occurs through vent holes or *if* battery electrolyte appears to be bubbling, reduce charging rate and continue to recheck until charging rate is adjusted to meet requirements in step d

    d. *If* there is no spewing or bubbling of electrolyte, continue charging

13. *If* battery is outside vehicle, shake or tilt battery at hourly intervals during charging to mix electrolyte

14. Check battery for charge: Battery is sufficiently charged when the green dot is visible in sight glass in built-in hydrometer

15. *If* green dot does **not** appear after allotted charging time has passed, battery must be replaced

16. Follow charger manufacturer's instructions for disconnecting charger from battery

► WARNING ◄

Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

17. Clean work area and return equipment and materials to proper storage

1399

JOB SHEET 8

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 22

Perform battery load test

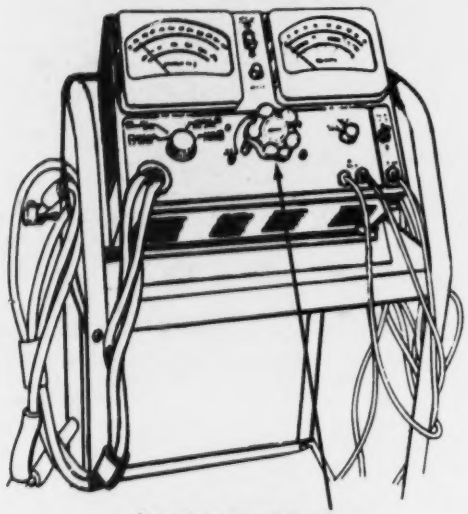
INTRODUCTION

The load test (sometimes called *capacity test*) is the most common and informative battery test used in automotive service. The test is so useful because it measures the battery's ability to deliver energy while it is working under a load (therefore, the more common name *load test*).

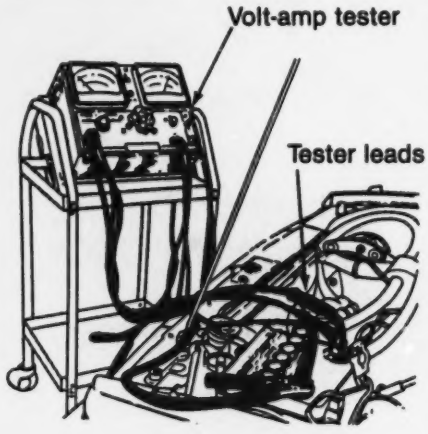
A load test can be performed with various pieces of test equipment, but the equipment most commonly used by automotive specialists is a volt-amp tester, see Figure 1 (a). As the name implies, the volt-amp tester combines an ammeter and a voltmeter with a resistance unit (load) that is adjusted with a load-control knob.

During use (see Figure 1 [b]), the volt-amp tester leads are connected to the battery terminals, and then the load-control knob is turned, adjusting the load placed on the battery until a specified current shows on the ammeter. The voltmeter is then read to obtain a measure of the battery's voltage after the load has been maintained for 15 seconds.

FIGURE 1



(a) Typical volt-amp tester



(b) Volt-amp-tester leads connected to battery during load test.

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1400

The following procedure provides safety guidelines and outlines the steps typically used in load-testing batteries; however, you must follow all general safety rules for dealing with batteries, study the manufacturer's instructions before operating the tester used in your shop, and understand the battery manufacturer's specifications or the automobile's service-manual procedure so you will know (1) how much load to place on the battery you will be testing and (2) how to interpret the results of the battery test.

EQUIPMENT AND MATERIALS

- Battery and battery-manufacturer's specifications
- Volt-amp tester and manufacturer's operating instructions
- Appropriate service manual
- Eye protection
- Rubber gloves
- Rubber apron
- Glass thermometer
- Pencil and paper

PROCEDURE

For load-testing a conventional battery

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is inside vehicle, place fender covers over fenders
3. *If* battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete
4. Perform visual inspection of battery; clean battery if necessary
5. Test battery temperature
   a. Remove a battery filler cap
   b. Insert thermometer into electrolyte in battery cell
   c. Record electrolyte-temperature reading
   d. *If* electrolyte temperature is less than 60 degrees F, allow temperature to rise and retest until temperature reads at least 60 degrees
   e. Leave thermometer in electrolyte
6. Test battery state of charge
   a. Perform battery state-of-charge test (Job Sheet 5)
   b. Record state-of-charge test results and compare test results to range specified by battery manufacturer or appropriate service manual

1401

c. *If* state of charge is **not** within range specified (normally 1.200 specific gravity at 80 degrees F), battery must be slow-charged (Job Sheet 7) and then retested

d. *If* after charge the battery state of charge is still **not** within range specified, battery must be replaced

e. Proceed with load test **only** *if* battery is within range specified

7. Prepare battery for load test

a. *If* battery is in vehicle, disconnect battery cables from terminals

► WARNING ◄

Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

(1) Disconnect grounded-terminal cable clamp

(2) Disconnect insulated-terminal cable clamp

b. *If* testing battery with side-mounted terminals, insert post adapters to provide a good connection for volt-amp-tester leads

8. Follow volt-amp-tester manufacturer's instructions for preparing tester for load test and for connecting tester leads to battery-terminal posts or adapters

► WARNING ◄

Connecting tester leads to battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

9. Refer to appropriate service manual or battery-manufacturer's specifications to determine correct load to place on specific battery being tested

NOTE: Some manufacturers provide specific load rates for their batteries; other manufacturers recommend that the load equal three times the ampere-hour rating or one-half the cold-cranking rating.

1402

10. Perform load test

    a. Remove surface charge from battery: Turn load-control knob until specified load has been placed on battery for 15 seconds; then immediately turn control knob to OFF position

    CAUTION

    Do not apply the load to the battery for more than 15 seconds. You will overheat the resistance unit in the tester.

    b. Wait 15 seconds and then turn load-control knob until specified load has been placed on battery for 15 seconds; quickly note voltage indicated on voltmeter; and immediately turn control knob to OFF position

    CAUTION

    Do not apply the load to the battery for more than 15 seconds.

11. Record voltmeter reading

12. Record electrolyte temperature, and remove thermometer from battery

13. Follow volt-amp-tester manufacturer's instructions for disconnecting tester from battery

    ► WARNING ◄

    Disconnecting the tester leads from the battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

14. Interpret load-test results

    a. Compare voltage and temperature readings to appropriate service manual or battery manufacturer's specifications

    NOTE: Most specifications will indicate that a battery is good when it will maintain a voltage of at least 9.6 volts while the specified load is applied when the electrolyte temperature is at 70 degrees F or above, but electrolyte temperature will affect the indicated voltage. Use the specifications to determine the minimum voltage allowable for temperatures lower than 70 degrees.

    b. *If* voltage reading is below the minimum specified, replace battery

c. *If* voltage reading is the same or exceeds the minimum specified, clean and slow-charge battery (Job Sheet 7) before returning it to service

15. Clean work area and return equipment and materials to proper storage

PROCEDURE

For load-testing a sealed battery

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is inside vehicle, place fender covers over fenders
3. *If* battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete
4. Perform visual inspection of battery; clean battery if necessary
5. Estimate battery temperature
   a. Determine temperature of environment battery was exposed to during the preceding few hours before testing
   b. Estimate battery temperature by touching battery
   c. Record estimated battery temperature
6. Test battery state of charge
   a. Perform battery state-of-charge check (Job Sheet 6)
   b. Record state-of-charge check results
   c. *If* red dot appears in built-in hydrometer, slow-charge battery (Job Sheet 7) until green dot is visible in hydrometer
   d. *If* hydrometer appears clear or light yellow, replace battery
   e. Proceed with load test **only** *if* green dot is visible in hydrometer
7. Refer to appropriate service manual or battery manufacturer's specifications to determine correct load to be placed on battery at temperature estimated in step 5
8. Prepare battery for load test
   a. *If* battery is in vehicle, disconnect battery cables from terminals

► WARNING ◄

Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

1404

(1) Disconnect grounded-terminal cable clamp

(2) Disconnect insulated-terminal cable clamp

b. *If* testing battery with side-mounted terminals, insert post adapters to provide a good connection for volt-amp-tester leads

9. Follow volt-amp-tester manufacturer's instructions for preparing tester for load test and for connecting tester leads to battery-terminal posts or adapters

► WARNING ◄

Connecting tester leads to battery in any other than the sequence recommended by tester manufacturer can cause the battery to explode.

10. Perform load test

a. Remove surface charge from battery: Turn load-control knob until specified load has been placed on battery for 15 seconds; then immediately turn control knob to OFF position

CAUTION

Do **not** apply the load to the battery for more than 15 seconds. You will overheat the resistance unit in the tester.

b. Wait 15 seconds and turn load-control knob until specified load has been placed on battery for 15 seconds; quickly note voltage indicated on voltmeter; and immediately turn control knob to OFF position

CAUTION

Do **not** apply the load to the battery for more than 15 seconds.

11. Record voltmeter reading

12. Follow manufacturer's instructions for disconnecting tester from battery

► WARNING ◄

Disconnecting tester from the battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

1405

13. Interpret load-test results

    a. Compare voltage and temperature readings to battery specifications

    b. *If* readings are below the minimum specified, replace battery

    c. *If* readings are the same or exceed the minimum specified, clean and slow-charge battery (Job Sheet 7) before returning it to service

14. Clean work area and return equipment and materials to proper storage

1406

JOB SHEET 9

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 23

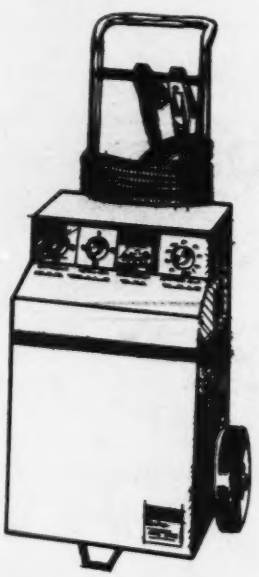
Perform three-minute charge test

INTRODUCTION

A three-minute charge test is a quick test used to determine whether a battery is simply discharged or really worn out (the battery has shorted out—the plates have been ruined).

To conduct the test, you connect a battery charger (see Figure 1) and a voltmeter to the battery. Next, you set the charger in the 20- to 50-amp range (40 amps being the maximum charge setting for automobiles and 50 amps for large trucks), turn the charger on for three minutes, take a reading from the voltmeter, and turn the charger off. The voltmeter reading is then interpreted to determine the condition of the battery.

FIGURE 1



The voltmeter reading taken during the test is interpreted using following guidelines.

- If the voltmeter reading is less than 15.5 volts, the battery is probably just discharged and will accept a charge. Slow-charge the battery before returning it to service.
- If the voltmeter reading is above 15.5 volts, the battery is probably really worn out and will not accept a charge. Replace the battery.

Setting the charger at the high charging rates required for this test makes the test less safe than when using the charger for slow-charging and, therefore, requires that you take greater care to protect the vehicle. For example, because of the lower charge rates used in slow-charging, you had the option of whether or not to remove the battery from the vehicle. For the three-minute charge test, you do not have that option—you *must* remove the battery

from the vehicle. Removing the battery from the vehicle's electrical system protects the system from surges that could cause severe damage and prevents extensive damage to the entire vehicle should the battery explode. General battery-safety guidelines must also be strictly adhered to during this procedure, especially the sequence used in connecting and disconnecting battery cables and charger leads. If you do not follow the correct sequence, a spark can result that can ignite battery gases and cause the battery to explode.

EQUIPMENT AND MATERIALS

- Battery and battery-manufacturer's specifications
- Adjustable, fast-rate charger and manufacturer's operating instructions
- Voltmeter
- Appropriate service manual
- Eye protection
- Rubber gloves
- Rubber apron
- Glass thermometer
- Pencil and paper

PROCEDURE

For charge-testing a conventional battery

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is in vehicle, place fender covers over vehicle fenders
3. *If* battery is in vehicle, disconnect battery cables from terminals

   ► WARNING ◄

   Because of the high charging rates used in this test, the battery must be disconnected from the vehicle's electrical system to prevent surges that could cause severe damage to the system.

   ► WARNING ◄

   Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

   a. Disconnect grounded-terminal cable clamp

   b. Disconnect insulated-terminal cable clamp

4. Remove battery from vehicle and place battery on insulated surface—rubber, plastic, or wood—**never** metal or concrete

   ► WARNING ◄

   Battery should be removed from the vehicle to prevent extensive damage to vehicle should battery explode during procedure.

1408

5. *If* testing battery with side-mounted terminals, insert post adapters to provide a good connection for charger

6. Check battery temperature

   a. Remove battery filler caps

   b. Look down into filler holes over battery cells, using flashlight beam *if* necessary in poorly lit area, and determine condition of battery electrolyte

   c. *If* electrolyte appears to be frozen or *if* ice crystals are visible in electrolyte, allow battery to thaw fully before continuing procedure

7. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate for specific battery

8. Record charge rate

9. Follow charger manufacturer's instructions for preparing charger for test and for connecting charger leads to battery-terminal posts or adapters

   ► WARNING: ◄

   Connecting charger leads to battery-terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

10. Hook voltmeter leads to charger cable clamps

11. Turn on charger and adjust charging rate

12. Charge battery for three minutes

13. With charger still charging, quickly take voltmeter reading

    NOTE: The charger must be charging the battery when the voltmeter reading is taken.

14. Turn charger off

15. Record voltmeter reading

16. Interpret charge-test results

    a. *If* voltmeter reading is less than 15.5 volts, the battery will probably accept a charge; clean and slow-charge battery (Job Sheet 7) before returning battery to service

b. *If* reading is above 15.5 volts, the battery will not accept a charge and must be replaced

17. Disconnect voltmeter and follow charger manufacturer's instructions for disconnecting charger from battery

► WARNING ◄

Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

18. Clean work area and return equipment and materials to proper storage

PROCEDURE

For charge-testing a sealed battery

1. Put on eye protection, rubber gloves, and rubber apron
2. *If* battery is in vehicle, place fender covers over vehicle fenders
3. *If* battery is in vehicle, disconnect battery cables from terminals

► WARNING ◄

Because of the high charging rate used in this test, the battery must be disconnected from vehicle's electrical system to prevent surges that could cause severe damage to the system.

► WARNING ◄

Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

a. Disconnect grounded-terminal cable clamp

b. Disconnect insulated-terminal cable clamp

4. Remove battery from vehicle and place on insulated surface—rubber, plastic, or wood—never metal or concrete

► WARNING ◄

Battery should be removed from the vehicle to prevent extensive damage to vehicle should battery explode during procedure.

5. *If* testing battery with side-mounted terminals, insert post adapters to provide a good connection for charger

1410

6. Check battery temperature

   a. Determine temperature of environment battery was exposed to during hours before testing

   b. *If* battery was exposed to subfreezing temperatures and battery appears frozen, allow battery to thaw fully before continuing procedure

7. Test battery state of charge

   a. Perform state-of-charge check (Job Sheet 6)

   b. Record state-of-charge check results

   c. *If* hydrometer appears clear or light yellow, do **not** proceed with testing procedure; replace battery

   d. Proceed with test only *if* red dot appears in built-in hydrometer

8. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate for specific battery

9. Record charge rate

10. Follow charger manufacturer's instructions for preparing charger for test and for connecting charger leads to battery-terminal posts or adapters

    ► WARNING ◄

    Connecting charger leads to battery-terminal posts or adapters in any other than the sequence recommended by the charger manufacturer can cause the battery to explode.

11. Hook voltmeter leads to charger cable clamps

12. Turn on charger and adjust charging rate

13. With charger still charging, quickly take voltmeter reading

    NOTE: The charger must be charging the battery when the voltmeter reading is taken.

14. Turn charger off

15. Record voltmeter reading

1411

16. Interpret charge-test results

    a. *If* voltmeter reading is less than 15.5 volts, the battery will probably accept a charge; clean and slow-charge battery (Job Sheet 7) before returning battery to service

    b. *If* reading is above 15.5 volts, the battery will **not** accept a charge and must be replaced

17. Disconnect voltmeter and follow charger manufacturer's instructions for disconnecting charger from battery

    ► WARNING ◄

    Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

18. Clean work area and return equipment and materials to proper storage

1412

JOB SHEET 10

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 24

Emergency jump-start a vehicle

INTRODUCTION

Jump-starting is a procedure used in an emergency to start a vehicle with a discharged battery. During the procedure, jumper cables, heavy electrical cables with terminal clamps at each end (see Figure 1), are connected between the discharged battery and a good battery, called the *booster battery*. The booster battery may be a separate battery brought to the vehicle with the discharged battery, or it may be a battery in another vehicle.

FIGURE 1

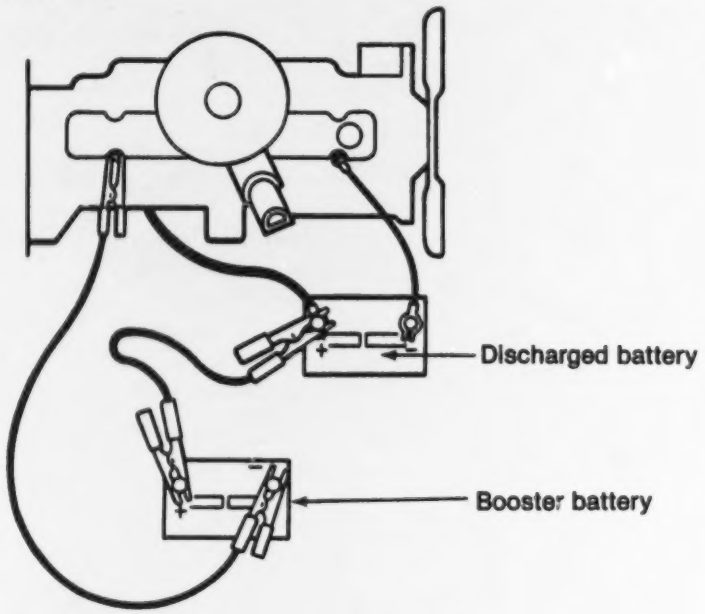
When jump-starting a vehicle, if you know how to connect jumper cables in the correct sequence, you can perform an important emergency service, but if you connect jumper cables improperly, serious damage can result—damage to automotive electrical systems and damage to you and any bystanders if the battery should explode. Incorrect connection procedures cause a spark that can ignite battery gases. Therefore, it is very important that you always follow the steps below when connecting jumper cables between two batteries.

1. Always begin the procedure by connecting one jumper-cable terminal clamp to the positive terminal of the booster battery (identified by a red color, "P", or "+" on the battery case or terminal) and the other end of the same cable to the positive terminal of the discharged battery. See Figure 2.

2. Then connect one end of the remaining jumper cable to the negative terminal of the booster battery (identified by a black color, "N", or "−" on the battery case or terminal) and the other end to a good ground—such as the engine block, frame, alternator bracket, or air-conditioner compressor bracket—that is at least 18 inches away from the discharged battery. See Figure 2.

   Never connect a booster battery directly to a discharged battery, and never try to ground the cable to any part of the vehicle's fuel system.

FIGURE 2



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While correctly making the cable connections is the most important aspect of safe jump-starting, the guidelines below should also be followed to ensure the safety and success of an emergency jump-start.

- Use only good-quality jumper cables made of 4-gauge or larger wiring. Never use cables made from aluminum wiring or cables that exceed 15 feet in length.
- Always wear safety glasses during the procedure. Never allow electrolyte to contact your eyes.

1414

- Wear protective clothing. Never allow electrolyte to contact your skin.
- Do not allow electrolyte to contact any part of the vehicle, especially the vehicle's finish.
- Do not smoke during the procedure or create sparks in any way; the battery gases may ignite and cause the battery to explode.
- Never attempt to jump-start a frozen battery. A frozen battery may rupture or explode during the procedure.
- If two vehicles are involved in the procedure, do not permit the vehicles to touch each other. This could establish a ground connection and counteract the benefits of the procedure.
- If the booster battery is in a vehicle, never start the engine of that vehicle. Extensive damage would result to the electrical systems of both vehicles involved in the procedure.

EQUIPMENT AND MATERIALS

- Vehicle with discharged battery
- Booster battery
- Jumper cables
- Paper towels or cloth
- Eye protection
- Protective clothing
- Container of water

PROCEDURE

For jump-starting a vehicle with a conventional battery

1. *If* using the booster battery in another vehicle, position vehicles so that they do **not** touch each other

   NOTE: Allowing the vehicles to touch can establish a ground that would counteract the benefits of the procedure.

2. Set parking brake; place vehicle with automatic transmission in PARK and vehicle with manual transmission in NEUTRAL

3. Turn off any electrical load in vehicle with discharged battery

   NOTE: Turn off lights and heater, remove the key from the ignition, and close vehicle doors.

4. Put on eye protection and protective clothing

5. Place fender covers over vehicle fenders

6. Prepare discharged battery for jump-starting procedure

   a. *If* ambient (air) temperature is below freezing, check condition of discharged battery's electrolyte

      ► WARNING ◄

      At temperatures below freezing, the electrolyte in a discharged battery may freeze. Do **not** attempt to jump-start a vehicle with a frozen battery. A frozen battery may rupture or explode if jump-start is attempted.

      (1) Remove battery filler caps

      (2) Look down into battery cells, using flashlight beam *if* necessary in poorly lit area, and determine condition of battery electrolyte

      (3) *If* electrolyte appears to be frozen or *if* ice crystals are visible in electrolyte, do **not** attempt jump-start; remove battery from vehicle, and take to a warm environment to allow battery to thaw fully

      (4) Proceed with jump-start only *if* battery is completely thawed

   b. Check electrolyte level

      (1) Look down into battery cells, using flashlight beam *if* necessary in poorly lit area, and determine electrolyte level

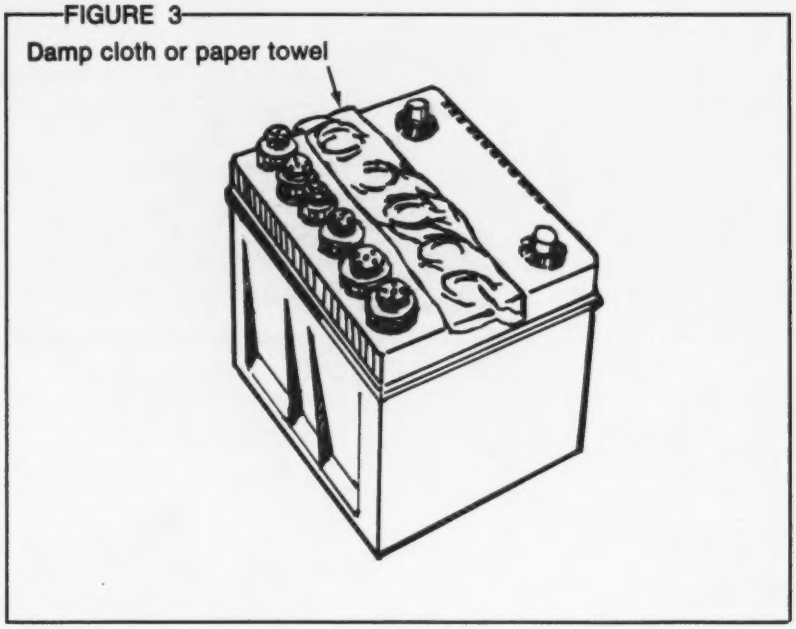
      (2) *If* electrolyte level is low, fill with water until electrolyte level is above tops of plates

   c. Cover filler holes with damp cloth or paper towel (see Figure 3)

      NOTE: Covering the filler holes with a cloth or paper towel will prevent the electrolyte from spewing from the filler holes during the jump-starting procedure.

1416

FIGURE 3



Adapted with permission of Chrysler Motor Corporation.

7. Connect jumper cables to batteries (see Figure 4)

► WARNING ◄

Connecting the jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

a. Connect one jumper-cable terminal clamp to positive terminal of booster battery

b. Connect terminal clamp at other end of same jumper cable to positive terminal of discharged battery

c. Connect one terminal clamp of remaining jumper cable to negative terminal of booster battery

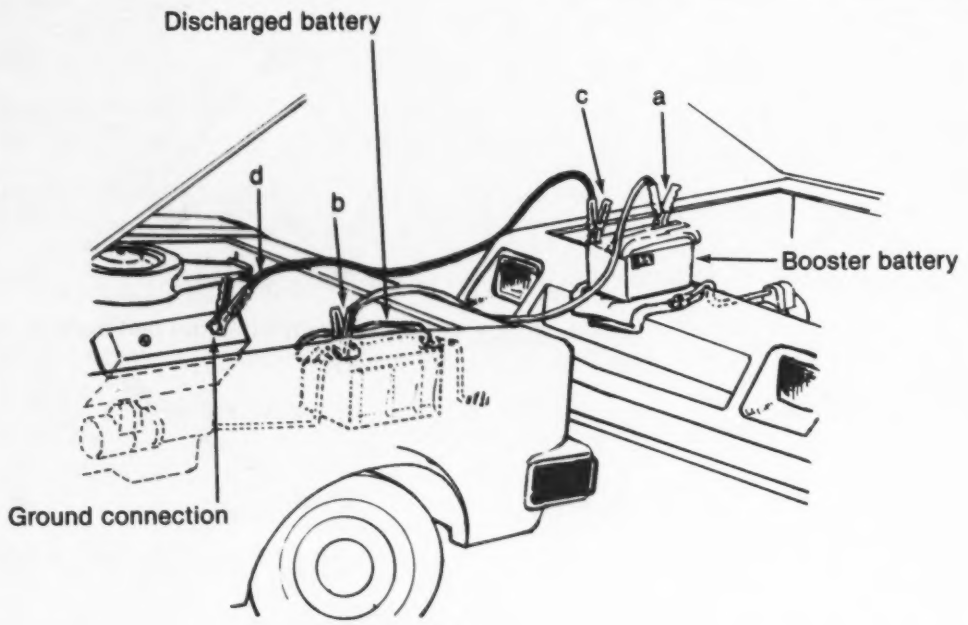
d. Connect remaining terminal clamp of same cable to a **good** ground at least 18 inches away from discharged battery

► WARNING ◄

Never connect a booster battery directly to the discharged battery. **Never** ground cable to any part of the vehicle's fuel system.

1417

FIGURE 4



Sequence for connecting jumper cables

8. Place key in ignition of vehicle with discharged battery and attempt to start engine

► WARNING ◄

If booster battery is in another vehicle, battery should be disconnected from that vehicle's electrical system. **Never** leave booster battery connected to electrical system and **never** start the engine of that vehicle. Extensive damage would result to the electrical systems of both vehicles.

9. Disconnect jumper cables

NOTE: Disconnect jumper cables whether or **not** the vehicle starts on the first try. Further attempts at jump-starting the vehicle will only run down the booster battery.

► WARNING ◄

Disconnecting the jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

a. Disconnect jumper-cable terminal clamp from ground on engine

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b. Disconnect jumper-cable terminal clamp from negative terminal of booster battery

c. Disconnect jumper-cable terminal clamp from positive terminal of discharged battery

d. Disconnect jumper-cable terminal clamp from positive terminal of booster battery

10. Remove damp cloth or paper towel covering filler holes on discharged battery

11. Install battery filler caps

12. Clean work area and return equipment and materials to proper storage

PROCEDURE

For jump-starting a vehicle with a sealed battery

1. *If* using a booster battery in another vehicle, position vehicles so that they do **not** touch each other

   NOTE: Allowing the vehicles to touch can establish a ground that would counteract the benefits of the procedure.

2. Set parking brake; place vehicle with automatic transmission in PARK and vehicle with manual transmission in NEUTRAL

3. Turn off any electrical load in vehicle with discharged battery

   NOTE: Turn off lights and heater, remove the key from the ignition, and close vehicle doors.

4. Put on eye protection and protective clothing

5. Place fender covers over vehicle fenders

6. Prepare discharged battery for jump-starting procedure

   a. Determine temperature of environment battery was exposed to during preceding hours

   b. *If* battery was exposed to subfreezing temperatures and battery appears frozen, do **not** attempt jump-start; remove battery from vehicle, and take to a warm environment to allow battery to thaw fully

   ► WARNING ◄

   At temperatures below freezing, the electrolyte in a discharged battery may freeze. Do **not** attempt to jump-start a vehicle with a frozen battery. A frozen battery may rupture or explode if jump-start is attempted.

1419

c. Check battery state of charge (Job Sheet 6)

d. *If* hydrometer appears clear or light yellow, do **not** proceed with jump-starting procedure; replace battery

e. Proceed with jump-start procedure only *if* red dot appears in built-in hydrometer and battery is completely thawed

7. Connect jumper cables to batteries (See Figure 4)

► WARNING ◄

Connecting jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

a. Connect one jumper-cable terminal clamp to positive terminal of booster battery

b. Connect terminal clamp at other end of same jumper cable to positive terminal of discharged battery

c. Connect one terminal clamp of remaining jumper cable to negative terminal of booster battery

d. Connect remaining terminal clamp of same cable to a **good** ground at least 18 inches away from discharged battery

► WARNING ◄

Never connect a booster battery directly to the discharged battery. **Never** ground cable to any part of the vehicle's fuel system.

8. Place key in ignition of vehicle with discharged battery and attempt to start engine

► WARNING ◄

If booster battery is in another vehicle, battery should be disconnected from that vehicle's electrical system. **Never** leave booster battery connected to electrical system and **never** start the engine of that vehicle. Extensive damage would result to the electrical systems of both vehicles.

1420

9. Disconnect jumper cables

NOTE: Disconnect jumper cables whether or **not** the vehicle starts on the first try. Further attempts at jump-starting the vehicle will only run down the booster battery.

► WARNING ◄

Disconnecting jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

a. Disconnect jumper-cable terminal clamp from ground on engine

b. Disconnect jumper-cable terminal clamp from negative terminal of booster battery

c. Disconnect jumper-cable terminal clamp from positive terminal of discharged battery

d. Disconnect jumper-cable terminal clamp from positive terminal of booster battery

10. Clean work area and return equipment and materials to proper storage

1421

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 1

Solder-splice electrical wiring

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly stripped wire and cleaned exposed wiring.	_____	_____
3. Properly prepared soldering iron or gun for use.	_____	_____
4. Followed correct procedure for solder-splicing connection.	_____	_____
5. Properly reinsulated solder-spliced connection.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1422

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1483

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 2

Install terminals and connectors

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly stripped wire and cleaned exposed wiring.	_____	_____
3. Followed correct procedure for installing a solderless connector or terminal.	_____	_____
4. Followed correct procedure for installing a soldered terminal or connector.	_____	_____
5. Properly reinsulated connection.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1424

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1485

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 3

Measure current, voltage, and resistance with a multimeter

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed correct procedure for measuring circuit current.	_____	_____
3. Recorded correct amperage reading.	_____	_____
4. Followed correct procedure for measuring circuit voltage.	_____	_____
5. Recorded correct voltage reading.	_____	_____
6. Followed correct procedure for measuring resistance.	_____	_____
7. Recorded correct ohms reading.	_____	_____
8. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1426

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1497

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 4

Test and replace miniature light bulbs and test their sockets

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Followed correct procedure for exposing and inspecting bulb.	_____	_____
3. Obtained proper replacement bulb as necessary.	_____	_____
4. Followed correct procedure for testing light socket.	_____	_____
5. Followed correct procedure for installing bulb and socket.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1428

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1489

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 5

Perform state-of-charge test on a conventional battery

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure if necessary.	_____	_____
3. Properly prepared battery for procedure.	_____	_____
4. Followed correct procedure for obtaining hydrometer readings.	_____	_____
5. Recorded correct readings.	_____	_____
6. Properly interpreted test results.	_____	_____
7. Selected correct replacement battery as necessary.	_____	_____
8. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1430

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1431

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 6

Perform state-of-charge check on a sealed battery

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure if necessary.	_____	_____
3. Properly prepared battery for procedure.	_____	_____
4. Followed correct procedure for obtaining hydrometer readings.	_____	_____
5. Properly interpreted and recorded battery state of charge.	_____	_____
6. Selected correct replacement battery as necessary.	_____	_____
7. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

1432

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1433

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 7

Slow-charge a battery

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure if necessary.	_____	_____
3. Properly prepared battery for procedure.	_____	_____
4. Correctly determined charge rate and time for specific battery.	_____	_____
5. Correctly followed charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery terminals/adapters.	_____	_____
6. Properly adjusted charging rate and time.	_____	_____
7. Correctly checked battery for full charge.	_____	_____
8. Correctly followed charger manufacturer's instructions for disconnecting charger from battery.	_____	_____
9. Correctly interpreted state-of-charge test results.	_____	_____
10. Selected correct replacement battery as necessary.	_____	_____
11. Followed correct procedure for installing battery if necessary.	_____	_____
12. Cleaned work area and properly stored equipment and materials.	_____	_____

1434

EVALUATOR'S COMMENTS

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 8

Perform battery load test

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure if necessary.	_____	_____
3. Properly inspected and prepared battery for procedure.	_____	_____
4. Followed volt-amp-tester manufacturer's instructions for preparing tester for load-test and connecting tester leads to battery.	_____	_____
5. Followed correct procedure for performing load-test.	_____	_____
6. Recorded correct reading.	_____	_____
7. Followed manufacturer's instructions for disconnecting tester from battery.	_____	_____
8. Correctly interpreted test results.	_____	_____
9. Selected correct replacement battery as necessary.	_____	_____
10. Followed correct procedure for installing battery.	_____	_____
11. Cleaned work area and properly stored equipment and materials.	_____	_____

1436

EVALUATOR'S COMMENTS

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

1437

PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 9

Perform three-minute charge test

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle for procedure if necessary.	_____	_____
3. Properly inspected and prepared battery for procedure.	_____	_____
4. Followed charger manufacturer's instructions for preparing charger for test and connecting charge leads to battery.	_____	_____
5. Correctly hooked voltmeter leads to charger cable clamps.	_____	_____
6. Followed correct procedure for performing three-minute charge test.	_____	_____
7. Recorded correct voltmeter reading.	_____	_____
8. Correctly interpreted test results.	_____	_____
9. Selected correct replacement battery as necessary.	_____	_____
10. Followed correct procedure for installing battery.	_____	_____
11. Cleaned work area and properly stored equipment and materials.	_____	_____

1438

EVALUATOR'S COMMENTS

_____

_____

_____

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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PRACTICAL TEST

APPLY RELATED ELECTRICAL PRINCIPLES

JOB SHEET 10

Emergency jump-start a vehicle

Student's name _____ Date _____

Evaluator's name _____ Attempt no. ____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

Evaluator note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle(s) and batteries for procedure.	_____	_____
3. Followed correct procedure for connecting jumper cables to batteries.	_____	_____
4. Followed correct procedure for jump-start.	_____	_____
5. Followed correct procedure for disconnecting jumper cables from batteries.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____

EVALUATOR'S COMMENTS

_____

_____

_____

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PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See "Performance Evaluation Key.") A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

_____

_____

_____

AVERAGE RATING

Evaluator note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 - Skilled—Can perform job with no additional training
3 - Moderately skilled—Has performed job during training program; limited additional training may be required
2 - Limited skill—Has performed job during training program; additional training is required to develop skill
1 - Unskilled—Is familiar with process, but is unable to perform job

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WRITTEN TEST

APPLY RELATED ELECTRICAL PRINCIPLES

Name _____ Score _____

OBJECTIVE 1

Choose the definitions that best define the following terms associated with automotive electrical systems. Write the correct numbers in the blanks.

_____a. **Circuit**

1. Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits
2. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
3. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

_____b. **Primary wire**

1. Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits
2. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires
3. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

_____c. **Secondary wire**

1. Low-tension conductor used for low-voltage ignition, lighting, and accessory circuits
2. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires
3. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

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_____d. **Wiring harness**

1. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source
2. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
3. High-tension conductor used for high-voltage ignition circuits, as in spark-plug and coil wires

_____e. **Wiring diagram (schematic)**

1. System of wires that are taped together and designed to supply power to electrical devices throughout a vehicle
2. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source
3. Drawing that uses electrical symbols to show electrical circuits

OBJECTIVE 2

Write the electron theory of electricity. Use the lines below to write the five statements derived from the theory.

a. _____

_____

b. _____

_____

c. _____

_____

_____

d. _____

_____

_____

e. _____

_____

_____

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OBJECTIVE 3

Distinguish between conductors and insulators. On the lines below, describe electron flow through each type of material and then state the correct use of each.

Conductor

a. Description — _____

_____

b. Use — _____

_____

Insulator

a. Description — _____

_____

b. Use — _____

_____

OBJECTIVE 4

Write the name of the basic electrical measurement that should be used to measure each electrical property described below.

a. _____ — Measures the amount of electrical pressure causing electrons to flow

b. _____ — Measures the amount of opposition offered to the flow of electrons by the substance through which it is passing

c. _____ — Measures the number of electrons flowing past a given point per second

OBJECTIVE 5

Write the purpose of each of the components of a basic electrical circuit.

a. **Energy source** — _____

_____

_____

_____

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b. **Conductors** — _____

_____

_____

_____

c. **Load** — _____

_____

_____

_____

d. **Switch** — _____

_____

_____

_____

OBJECTIVE 6

Label each of the following illustrations of types of electrical circuits and then state the correct description of each type.

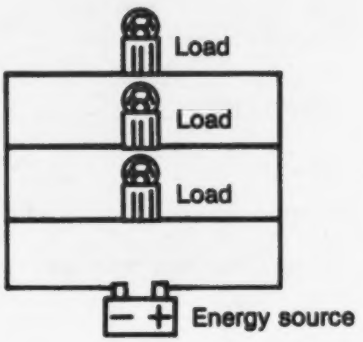

Illustration a

1. Circuit type — _____

1445

2. Description — _____

_____

_____

_____

_____

_____

_____

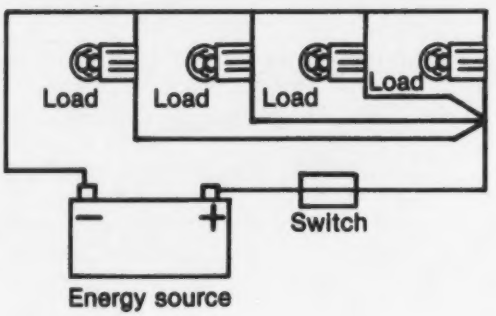

Illustration b

1. Circuit type — _____

2. Description — _____

_____

_____

_____

_____

_____

_____

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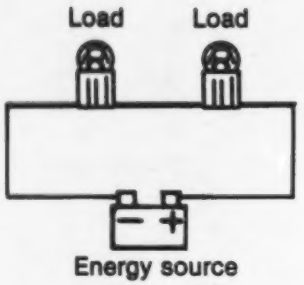

Illustration c

1. Circuit type — _____
2. Description — _____

_____

_____

_____

_____

_____

_____

OBJECTIVE 7

Describe electron flow through a single-wire circuit to explain how this type of circuit functions.

Single-wire-circuit function — _____

_____

_____

_____

_____

_____

_____

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OBJECTIVE 8

Match the following electrical-circuit problems to their correct descriptions. Write the correct numbers in the blanks.

_____a. Condition caused by a break in a circuit, causing current to stop flowing through the circuit

_____b. Condition caused when current bypasses a part of an intended circuit, causing current to flow in an accidental circuit

_____c. Condition caused when a conductor in an intended circuit touches a conductor in another circuit, causing current to flow in the other circuit and power a different load

_____d. Condition caused when a conductor in an intended circuit touches a ground connection, creating an accidental ground

_____e. Condition usually caused by a loose or badly corroded connection, causing a reduction of current flowing in a circuit

1. High-resistance circuit
2. Open circuit
3. Wire-to-wire short circuit
4. Short-to-ground circuit
5. Short circuit

OBJECTIVE 9

Label each of the following illustrations of types of circuit-protection devices and then describe how their designs affect current flow through a circuit.

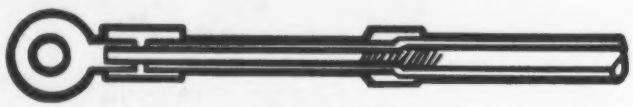

Illustration a

1. Circuit-protection device — _____
2. Description — _____

_____

_____

_____

_____

Illustration b

1. Circuit-protection device — _____
2. Description — _____

_____

_____

_____

_____

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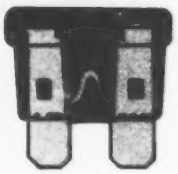

Illustration c

1. Circuit-protection device — _____
2. Description — _____

_____

_____

_____

_____

OBJECTIVE 10

State the type of electrical test equipment that should be used for each of the situations described below.

Situation a — Bypassing a portion of a circuit

Test equipment used — _____

Situation b — Measuring voltage, current, and resistance

Test equipment used — _____

Situation c — Checking to see that voltage is present in a circuit

Test equipment used — _____

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OBJECTIVE 11

Interpret electrical values from various digital multimeter settings. Write the correct multimeter reading in the blank under each of the following illustrations.

Illustration a

Multimeter reading

_____

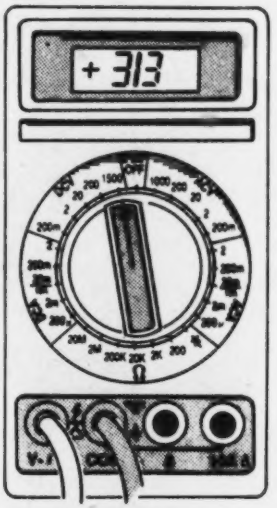

Illustration b

Multimeter reading

_____

Illustration c

Multimeter reading

_____

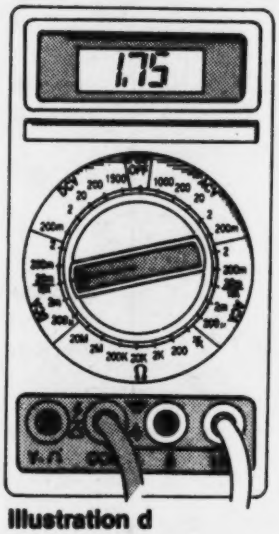

Illustration d

Multimeter reading

_____

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OBJECTIVE 12

Interpret automotive-circuit wiring diagrams. Study the wiring diagram printed on the following page and then answer the following questions. Write the correct answers on the blanks provided.

a. What type of stator does the alternator contain?

Type of stator _____

b. What is the function of circuit A2?

Circuit function _____

c. What is the purpose of circuit C13?

Circuit purpose _____

d. What is the size and color of the alternator-output wire?

Wire size and color _____

e. What circuit feeds the hazard flasher?

Circuit _____

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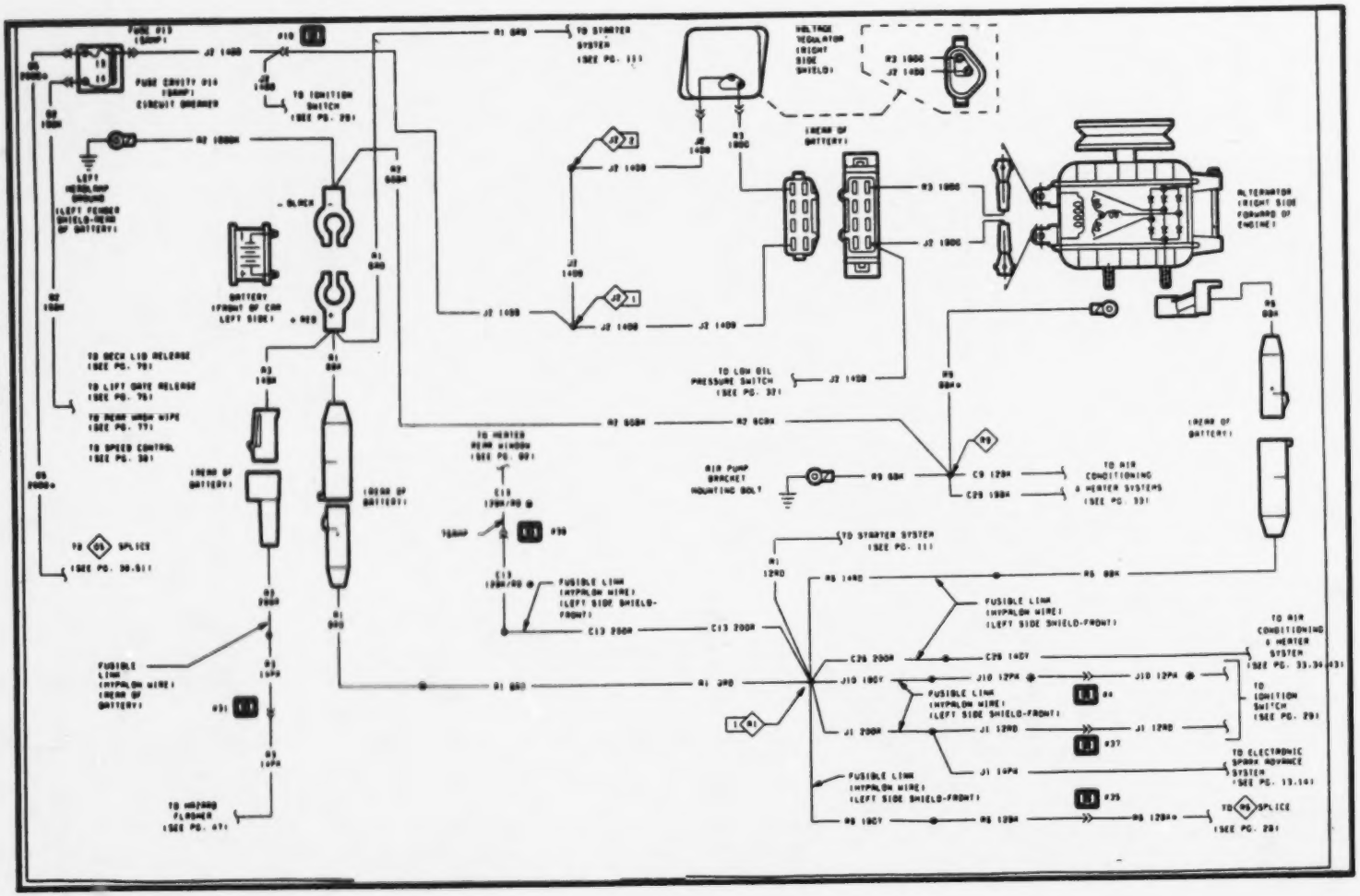

Used with permission of Chrysler Motor Corporation.

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OBJECTIVE 17

Describe electron flow in a battery during charging, discharging, and recharging.

Charging

1. _____

2. _____

3. _____

Discharging

1. _____

2. _____

3. _____

4. _____

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Recharging

1. _____

_____

_____

_____

_____

2. _____

_____

_____

OBJECTIVE 18

State safety practices to follow when working with batteries. For each word or phrase below, write the safety rule that goes with that word or phrase.

a. Safety glasses, rubber gloves, and a rubber apron — _____

_____

_____

b. Fender covers — _____

_____

_____

c. Baking soda and water — _____

_____

_____

d. Smoke — _____

_____

_____

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e. Live circuits — _____

_____

_____

f. Disconnecting and reconnecting battery cables — _____

_____

_____

_____

g. Using a battery charger — _____

_____

_____

h. Conductor and battery terminals — _____

_____

_____

i. Frozen battery — _____

_____

_____

j. Connecting jumper cables to battery — _____

_____

_____

k. Sealed battery with clear or light yellow hydrometer — _____

_____

_____

_____

l. Metal rings or jewelry — _____

_____

_____

NOTE: Turn in your test to your instructor, who will grade the test and determine whether additional training is needed.

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WRITTEN TEST ANSWERS

APPLY RELATED ELECTRICAL PRINCIPLES

OBJECTIVE 1

a. 3
b. 1
c. 2
d. 2
e. 3

OBJECTIVE 2

a. Everything is made up of atoms
b. Atoms are made up of three elementary particles: protons, neutrons, and electrons
c. Protons, which carry a positive charge (+), and neutrons, which carry no charge, make up the center of the atom, called the *nucleus*
d. Electrons, which carry a negative charge (−), revolve around the nucleus in paths called *orbits*; electrons in the outer orbit are called *free electrons*
e. In some elements, when free electrons are energized, they move (flow) from one atom to another; this flow of electrons is called *electricity*

OBJECTIVE 3

Conductor

a. Material that allows electrons (electricity) to flow through it easily
b. Used to provide a pathway for electricity

Insulator

a. Material that resists electron flow (electricity)
b. Used to keep electricity within bounds

OBJECTIVE 4

a. Volt (V or E)
b. Ohm (Ω or R)
c. Ampere (Amp, A, or I)

OBJECTIVE 5

a. Produces the energy that causes electrons to flow
b. Provide pathway through which electrons flow from energy source through load and back to energy source
c. Converts electrical energy into some other form of energy—heat, light, or mechanical energy
d. Opens and closes circuit

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OBJECTIVE 6

a. 1. Parallel circuit
   2. Circuit has more than one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any one path, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

b. 1. Series-parallel circuit
   2. Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel paths of the circuit; should an open occur in the path in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths of the parallel portion of the circuit, current stops flowing through that path and to the load on that path but continues flowing through other paths and to their loads

c. 1. Series circuit
   2. Circuit has only one path for electricity to flow from energy source through loads (and switches) and then back to energy source; should an open occur in any circuit component, current stops flowing through circuit and to all loads

OBJECTIVE 7

Single-wire-circuit function — Circuit uses vehicle's frame as a part of the circuit: electrons flow from negative battery terminal through frame, through load, back along insulated wire, through switch, and then to positive battery terminal

OBJECTIVE 8

a. 2
b. 5
c. 3
d. 4
e. 1

OBJECTIVE 9

a. 1. Fusible link
   2. Specially insulated wire connected in circuit; designed so that insulation puffs and smokes and then wire melts and permanently opens circuit when excessive current flows through it

b. 1. Circuit breaker
   2. Device containing a bimetal strip and a set of points; designed so that when excessive current flows through it, bimetal strip bends away from contact points and temporarily opens circuit until strip cools and again touches contact points

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c. 1. Fuse
2. Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that soft-metal conductor melts (burns out) and permanently opens circuit when excessive current flows through it

OBJECTIVE 10

a. Jumper wires
b. Multimeter
c. Test light

OBJECTIVE 11

a. 4.40 amps
b. 313 volts positive
c. 135 ohms
d. 1.75 amps

OBJECTIVE 12

a. Y-wound stator
b. Left headlamp ground
c. Powers heated rear window
d. 8-gauge, black
e. A3

OBJECTIVE 17

Charging

1. Two plates made from dissimilar conductors (lead peroxide and spongy lead) are placed in the sulfuric-acid-and-water solution called *electrolyte*
2. Acid attacks lead-peroxide plate (positive plate), releasing electrons that are attached to spongy-lead plate (negative plate)
3. Negative plate becomes full of electrons—the battery is charged

Discharging

1. Battery circuit is closed
2. Potential (voltage) causes electrons to flow through circuit to load, pulling electrons away from negative plate
3. As electrons are pulled away from negative plate, plates become similar in composition and acid in electrolyte decreases
4. As positive and negative plates become more similar, battery voltage decreases—battery becomes weaker and will eventually be discharged if the battery is not recharged

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Recharging

1. Direct current is forced through battery (from alternator or battery charger), supplying electrons to positive plate, making positive and negative plates become dissimilar again and building up acid in electrolyte
2. Again the acid in the electrolyte attacks positive plate and electrons go to negative plate—the battery returns to a charged condition

OBJECTIVE 18

a. Always wear safety glasses, rubber gloves, and a rubber apron when working with batteries
b. Use fender covers to protect vehicle finish and metal surfaces from accidental electrolyte spillage
c. Always keep a mixture of baking soda and water nearby when working with batteries
d. Do **not** smoke near a battery on charge or recently charged
e. Do **not** break live circuits at battery
f. When disconnecting battery cables, always disconnect grounded-terminal cable clamp (negative cable) first, and when reconnecting cables, always reconnect insulated-terminal cable clamp (positive cable) first
g. When using a battery charger, make connections before plugging charger into power supply
h. **Never** lay any conductor across battery terminals
i. Do **not** attempt to jump-start a battery that may be frozen
j. When connecting jumper cables to battery, always connect ground to vehicle frame or engine away from battery
k. **Never** charge, test, or jump-start a sealed battery when hydrometer appears clear or light yellow
l. **Never** wear metal rings or jewelry near battery

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